SUPPLY AND SERVICES CANADA

FEASIBILITY STUDY TO ESTABLISH A COMMUNITY HEATING SYSTEM TOWN OF SPRINGHILL, N.S.

FINAL REPORT

Vaughan
Engineering
Associates
Limited

MAY 1992

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MICROMEDIA

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FEASIBILITY STUDY TO ESTABLISH A COMMUNITY HEATING SYSTEM IN THE TOWN OF SPRINGHILL, N.S. USING WARM MINE WATER

FINAL REPORT

BY

VAUGHAN ENGINEERING ASSOCIATES LIMITED

Work on this project was conducted under the auspices of the Department of Energy Mines and Resources. This work was supported (in part) by the Federal Panel on Energy R & D.

DSS FILE NUMBER: 34SQ. 23440-1-9093

DSS CONTRACT NUMBER: 23440-1-9093/01-SQ

CANMET SCIENTIFIC AUTHORITY: L.A. CIAVAGLIA

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SECTION 1

EXECUTIVE SUMMARY

1.0 EXECUTIVE SUMMARY

The purpose of this study is to assess the feasibility of providing a community heating system for the Town of Springhill, using flooded coal mines as the principal heating and cooling source. Some localized applications have been implemented quite successfully in the past, including two industrial and one commercial application, and several others are currently under review. While past reports have been prepared on the mine water potential as a source and the needs of the Town in terms of demand, this study focused on reviewing various methods, and evaluating in detail the best, most cost effective method, of fully utilizing this resource relative to the demand and the source. This study compared the use of conventional oil and electricity fuels, as a baseline, to a full range of alternatives including local geothermal wells, district mine water distribution, and medium temperature hot water. Since it is very time consuming to analyze the entire Town, a candidate group of buildings was selected for the study which can be used for a future demonstration project, or extrapolated for the remainder of the Town.

The findings of this report indicate that the economics of geothermal conversion depend very significantly on the energy usage characteristics of the buildings under consideration. The single most significant parameter upon which geothermal conversion feasibility depends, is the necessity of cooling, or dehumidification, in addition to space heating. By establishing that this is a mandatory criteria for conversion of a facility, then the capital cost for a geothermal based system is only a small incremental cost above a conventional heating & cooling system, and the payback periods can be quite attractive (this has been the experience of Ropak Can Am Ltd. who have recently converted to a geothermal heating and dehumidification system). On the other hand, the "heat only" applications can have payback periods in the order of several years or more. Consequently, the Town would be advised to actively promote geothermal energy to industries that have significant cooling or dehumidification requirements, in addition to space heating or process needs. The Ropak Can Am building is an excellent example of the kind of industry that should be attracted to the Town.

This study evaluated the commercial and industrial applications of this technology for existing Town buildings, and for new industries that may be attracted to the Town. Because there are really only two industrial size buildings in the Industrial Park at present (Ropak and MBB), an extrapolation for future industrial expansion is difficult at best and, consequently, a hypothetical model was used to determine

the viability of this resource for new industries. For the commercial sector, the main street and commercial buildings in the Park were used to review the cost effectiveness of geothermal conversion for existing commercial building applications.

The application of a single central station (which would pump warm Town water, heated from the mine water by a heat exchanger, to local heat pumps), for the entire Town appears to be totally uneconomic, due to the distance separating the Town core and the Industrial Park and the related significant piping system costs. Consequently, separate smaller, more localized central systems are suggested for defined, limited areas in the Town. The most cost effective scheme for the Industrial Park appears to be a continuation of the present application, i.e. localized wells for individual plants. Should there be a large expansion in the future of, say, several buildings at one time, then a single "cluster" approach should be considered for that development at that time. Along the Main Street area, a single plant approach could be considered, although the economics still appear to be more favourable for the localized approach. Therefore, a smaller group of 11 buildings, which are in close proximity to each other, were identified as a potentially viable project, and a detailed economic analysis was performed for a single system supplying this group of buildings.

A central plant district heating system alternative (which would circulate medium temperature hot water from a central, large heatpump installation to each building) was also analysed, however, the results indicated poor economic viability for several reasons. First of all, because of the water temperature, this alternative requires a parallel piping system for the cooling mode, which is very expensive. Secondly, operators are to run the plant, which are not required for the warm water system described above. Thirdly, high temperature heatpumps are extremely costly. All of these factors increase the overall cost and make this option totally uneconomical. One has to consider, as well, that the candidate group of buildings represents a very small heating load, considerably smaller than applications where district heating is typically employed, such as university campuses and hospital complexes or to serve major residential loads such as entire towns, as is done in Sweden. Future applications of this resource in other communities would necessitate a group of buildings of significant size to justify the application of medium to high temperature district heating/cooling technology.

In the review of the supply side of this resource it was discovered that, at this time, there are more questions that can be raised than answers. While it appears, from the current experience and the previous assessments which have been carried out, that the capacity of the warm mine water reservoir is ample for development of this resource, this has not been proven conclusively as yet. Long term flow testing of the mine water needs to be completed to establish the extent of the resource with some accuracy, and to ensure that future users will not be burdened with insufficient flow or temperature. The industrial conversions to date will, in time, approximate the long term capacity of this resource, however, some funding should be committed to extended testing in the near future. This will enhance the reliability of the future development of the resource, and will provide a catalyst, in the future marketing of the resource, to attract new businesses to the Town.

It is concluded that conversion of existing buildings to geothermal energy is feasible provided a requirement for cooling is an accepted criteria, and the use of this resource in new buildings requiring heating and cooling is definitely feasible. The development approach for the Town core should be small "clusters" of buildings connected to small central pumping stations, drawing from a single well, or several wells adjacent to each other connected in tandem, with local heat pumps in each building supplied with warm water from this system via conventional PVC underground piping. The Industrial Park system could also be developed using this scheme provided the buildings were close enough together and the number of buildings could be accurately predicted. Otherwise, the individual well approach will be the most feasible for the Park.

It is recommended that the Town of Springhill continue to promote the resource to new businesses which may be interested in locating or relocating to Springhill, and to other targeted markets. It is also recommended that a small scale demonstration project be implemented in the near future using the candidate group of buildings identified in this report. The Town is advised to enquire about grants and assistance to offset the costs of this demonstration project and for a flow testing program, which should be initiated as soon as possible.

As a future revenue generator for the Town, the economics are such that the Town should consider only a break even approach to the implementation of the geothermal energy system, at least initially, and depend on the increased economic activity which the development will stimulate to increase the revenue for the Town.

SECTION 2

SELECTION AND EVALUATION OF CANDIDATE BUILDINGS

2.0 SELECTION AND EVALUATION OF CANDIDATE BUILDINGS

2.1 SELECTION OF BUILDINGS

A group of 36 buildings was initially selected for the analysis, including 5 buildings in the industrial park and 31 buildings in the Town core. The objective was to analyze these buildings and extrapolate the results to the overall Town, and also to identify an optimal group of buildings for a future demonstration project. The candidate buildings considered are indicated as buildings 1 to 36 in Figure 1, and are also shown on the site plan which is located at the end of this report. The following criteria was used for the selection of these buildings:

- representative of building types in Town;
- building owners interested in geothermal;
- centrally located in Town core and Industrial Park;
- located in close proximity to mine water source.

The Springhill hospital and Springhill Institution were not included in the selected group of buildings. The Institution is too far from the main part of Town and would involve enormous piping system costs. The hospital is also a significant distance from the core part of the Town, and with considerable cooling and heating loads year round, would better benefit from internal heat sharing through energy management practices. Other buildings that were not included in the candidate group are either too far from the main core or are represented by other building types in the group. Of course, in the event that a demonstration project is initiated, the group of buildings can be refined to include alternative buildings not included with the original group (subject to load capacity of the main supply/return lines).

As described later in this report, three separate schemes were evaluated for heating and cooling these buildings utilizing the mine water resource. These were:

- individual well and heatpump system for each building;
- warm water distribution system from a central pumping station with localized heatpumps;
- medium temperature hot water district heating system from a central heating plant utilizing large heatpumps.

Building With Oil/ Elec.Heating(Town)	Area ft2	Area m2	Method of Heating	Cooling	Actual kWh/yr	Actual Elec. kWh/ft2	Adj. kWh/yr	Adj. Elec.(heat only) kWh/ft2	Adj. Elec.(heat only) kWh/m2	Fuel Oil L/yr	Fuel Oil Eq.kWh/yr	Total kWh/yr	Heat Energy (Eq.) kWh/ft2	Heat Energy (Eq.) kWh/m2	Max. Dem.(Eq.kW) Indiv. Building	Req'd Flow (USgpm)
1-United Church	7500	697	oil	n	21542	2.9	0	0.0	0.0	22013	165351	165351	22.0	237	96	68
2-Sportsman Record	3250	302	oil	n	20240	6.2	0	0.0	0.0	6425	48261	48261	14.8	160	28	20
3-Legion	8200	762	oil	n	79443	9.7	0	0.0	0.0	18169	136477	136477	16.6	179	79	56
4-R.F. Bev. Room	1380	128	elec	y	48500	35.1	24250	17.6	189.2	0	0	24250	17.6	189	14	10
5-K of P Lodge	5600	520	oil	n	9091	1.6	0	0.0	0.0	8433	63345	63345	11.3	122	37	26
6-Library	3400	316	oil	n	9645	2.8	0	0.0	0.0	18110	136034	136034	40.0	431	79	56
7-Pat King/Terries	2000	186	oil/elec	y	25851	13.0	15571	7.8	83.8	3295	24750	40321	20.2	217	23	17
8-Jeans Ladies Wr	1400	130	elec	y	37760	27.0	22656	16.2	174.2	0	0	22656	16.2	174	13	9
9-Town Hall	16000	1486	oil/elec	y	230100	14.4	92040	5.8	61.9	27794	208775	300815	18.8	202	174	124
10-Brown's Funeral	10024	931	oil/elec	y	31220	3.1	21854	2.2	23.5	5509	41381	63235	6.3	68	37	26
11-Wardropes Drug	6400	595	oil/elec	y	40920	6.4	13056	2.0	22.0	8501	63855	76911	12.0	129	45	32
12-Fire Hall	5500	511	elec	y	164720	29.9	98832	18.0	193.4	0	0	98832	18.0	193	57	41
13-CIBC	2750	256	oil	y	60630	22.0	0	0.0	0.0	9906	74409	74409	27.1	291	43	31
14-Elm St.Med.Center	6728	532	elec	y	110240	19.2	66144	11.5	124.3	0	0	66144	11.5	124	38	27
15-D&J Hardware	5000	465	oil	y	43860	8.8	0	0.0	0.0	9434	70864	70864	14.2	153	41	29
16-Arena	35000	3252	oil/elec	y	352800	10.1	23480	0.7	7.2	30189	226765	250245	7.1	77	145	103
17-Commun. College	61384	4774	oil	n	279360	5.4	0	0.0	0.0	65499	491997	491997	9.6	103	285	202
18-Fern&Rays Motel	10080	936	oil/elec	n	47520	4.7	38016	3.8	40.6	9814	73718	111734	11.1	119	65	46
19-Nursing Home	5100	474	oil	n	10728	2.1	0	0.0	0.0	28291	212508	212508	41.7	449	123	87
20-Sen.Ct.(Elgin)	10000	929	oil	n	70988	7.1	0	0.0	0.0	46860	351990	351990	35.2	379	204	145
21-Sen.Ct(Spruce)	12000	1115	oil	n	61573	5.1	0	0.0	0.0	46860	351990	351990	29.3	316	204	145
22-High School	78975	7337	oil/elec	n	784800	9.9	655857	8.3	89.4	31395	235824	891681	11.3	122	516	367
23-Ang.Church&Hall	7700	715	oil	n	31055	4.0	0	0.0	0.0	17408	130780	130780	17.0	183	76	54
24-Post Office	5390	501	oil	n	40420	7.5	0	0.0	0.0	14716	110539	110539	20.5	221	64	45
25-Junc.Rd School	14369	1335	elec	n	164100	11.4	131280	9.1	98.3	0	0	131280	9.1	98	76	54
26-Pioneer St.Club	4320	401	oil	n	12931	3.0	0	0.0	0.0	10384	78000	78000	18.1	194	45	32
27-Hicks & Lemoine	1250	116	elec	n	12358	9.9	9886	7.9	85.1	0	0	9886	7.9	85	6	4
28-Imperial Pizza	1350	125	oil	n	64980	48.1	0	0.0	0.0	1049	7880	7880	5.8	63	5	3
29-Sen.Ct(Jct.Rd-2)	21000	1951	oil	n	144075	6.9	0	0.0	0.0	46772	351329	351329	16.7	180	203	145
30-Sen.Rec.Center	8000	857	oil	n	11214	1.9	0	0.0	0.0	12578	94480	94480	15.7	169	55	39
31-Sen.Ct(Pine St.)	9000	836	elec	n	146753	16.3	117402	13.0	140.4	0	0	117402	13.0	140	68	48
Sub-Total	357050	33170			3169517	11.5	1330325	8.8	95.2	499404	3751281	5081605	17.0	186.1	2942	2090
32-Industrial Park (5 Buildings)	14800	1375	oil/elec		138558	9.4	77200	5.2	56.1	12687	95299	172499	11.7	125	100	71
Total	371850	34545			3308075	11.4	1407525	8.8	92.8	512091	3846579	5254104	17.1	184.2	3042	2161

Building With Heat Pumps (Town)	Area ft2	Area m2	Flow Req'd USgpm
1-A.Murray Center	7632	709	69
2-UIC Offices	1340	124	8
3-Brown's Furniture	4000	372	12
4-Marcat Flowers	1680	156	9.5
5-Pizza Delight	2400	223	15
Total	17052		113.5

Buildings With Heat Pumps (Industrial Park)	Area ft2	Area m2	Flow Req'd USgpm
1-Ro-pak	96000	8918	140
2-MBB Mech	12000	1115	64
Total	108000	10033	204

Energy Distribution Month	Eq.kWh
Jan	843547
Feb	762241
March	698017
April	482753
May	309978
June	137203
July	49800
Aug	60979
Sept	167893
Oct	335388
Nov	492916
Dec	748998
Total	5075507.

Load Composition Type	%
elec.	26.2
oil	73.8

Energy Demand Month	Eq.kW
Jan	2942
Feb	2766
March	2600
April	1850
May	1681
June	1399
July	1237
Aug	1094
Sept	1310
Oct	1578
Nov	2184
Dec	2651

Area Composition Type	%
elec.	19.0
oil	81.0

Temp. (deg C)	Duration (hours)	Load (Eq.kW)	% of Peak	Duration (hours)	% of Total	eq'd Flow (USgpm)
27	1	0	0.0	1	100.0	0
26	7	0	0.0	7	100.0	0
25	15	0	0.0	15	99.9	0
24	31	0	0.0	31	99.7	0
23	53	0	0.0	53	99.4	0
22	78	0	0.0	78	98.8	0
21	115	7	0.2	115	97.5	5
20	145	72	2.5	145	96.8	51
19	184	138	4.7	184	94.9	98
18	230	203	6.9	230	92.8	144
17	280	268	9.1	280	90.2	190
16	334	333	11.3	334	87.0	237
15	354	399	13.5	354	83.2	283
14	342	464	15.8	342	79.1	330
13	338	529	18.0	338	75.2	376
12	319	594	20.2	319	71.4	422
11	304	660	22.4	304	67.8	469
10	288	725	24.6	288	64.3	515
9	281	790	26.8	281	61.0	561
8	251	855	29.1	251	57.8	608
7	252	920	31.3	252	54.9	654
6	250	986	33.5	250	52.1	700
5	245	1051	35.7	245	49.2	747
4	254	1116	37.8	254	46.4	793
3	272	1181	40.1	272	43.5	839
2	310	1247	42.4	310	40.4	886
1	363	1312	44.8	363	36.9	932
0	330	1377	46.8	330	32.7	978
-1	274	1442	49.0	274	28.9	1025
-2	253	1507	51.2	253	25.8	1071
-3	217	1573	53.4	217	22.9	1117
-4	210	1638	55.7	210	20.5	1164
-5	187	1703	57.9	187	18.1	1210
-6	168	1768	60.1	168	15.9	1256
-7	183	1834	62.3	183	14.0	1303
-8	140	1899	64.5	140	12.1	1349
-9	127	1964	66.7	127	10.5	1395
-10	123	2029	69.0	123	9.1	1442
-11	105	2094	71.2	105	7.7	1488
-12	95	2160	73.4	95	6.5	1534
-13	89	2225	75.6	89	5.4	1581
-14	77	2290	77.8	77	4.4	1627
-15	72	2355	80.0	72	3.5	1673
-16	57	2421	82.3	57	2.7	1720
-17	44	2486	84.5	44	2.0	1766
-18	39	2551	86.7	39	1.5	1812
-19	32	2616	88.9	32	1.1	1859
-20	25	2682	91.1	25	0.7	1905
-21	16	2747	93.3	16	0.4	1951
-22	10	2812	95.6	10	0.3	1998
-23	5	2877	97.8	5	0.1	2044
-24	4	2942	100.0	4	0.1	2090
-25	1	3008		1		2137
-26	1	3073		1		2183
-27	1	3138		1		2229
-28	1	3203		1		2276
	8760			8760		

CANDIDATE GROUP ANALYSIS

Figure 1

The first scheme is not pertinent to the group of buildings being reviewed. After development and evaluation of the latter two scenarios, it was found that these concepts were not viable for the candidate group of 36 buildings already selected, for reasons discussed later in this report, so other building scenarios were assessed. The end result was selection of a second candidate group of 11 buildings in the Town core which were located in close proximity to each other. These buildings are shown separately on the site plan located at the end of the report. Concepts were subsequently developed and a new evaluation performed on this second group of buildings, relative to the geothermal resource.

2.2 LOAD ANALYSIS

2.2.1 Energy Consumption

The energy data for the original candidate group of buildings is shown in Figure 1, with a breakdown of energy usage for each facility presented in a variety of forms. Most of the Town is heated by light #2 fuel oil, and a small portion of the buildings are heated either entirely by, or supplemented by, electric heat. The energy consumption varies considerably with each building, from 7.1 kwh/ft^2 to 41.7 kwh/ft^2, with the average at about 17 kwh/ft^2.

The largest energy users will eventually be located in the Industrial Park, however, as the buildings in the Park which currently use geothermal energy are not included in the analysis, the remaining buildings in the park are basically commercial grade buildings with energy consumptions comparable to those located in the main street area.

The energy density of the buildings in the entire Town of Springhill are highest along the Main Street area, where the buildings are in close proximity to each other. The future energy density of the Industrial Park will be dependant entirely on the types of industries attracted to the park and their location.

2.2.2 Heating Load Duration

The heating load duration Curves are plotted in Figures 2 to 5, and are used to optimize the geothermal/supplemental heating requirements for the various options. The warm mine water system, as currently conceptualized, would utilize existing oil fired systems to supplement the heating requirements, and was sized to handle the cooling requirements and up to 95 % of the heating requirements.

2.2.3 Peak Heating Assessment

The peak heating assessment indicates that the buildings experience a general load increase as the outdoor temperature increases, and sharp peaks do not actually occur. Where there are so many different building types under consideration, there is an averaging effect, and the Town generally follows this trend. Topping up the demand can be achieved by using existing heating systems for the localized or warm water distribution options, and the oil fired system can be used to supplement the peaks that may occur for the medium temperature district heating system, however dramatic peaks for a centralized Town system according to the analysis do not occur.

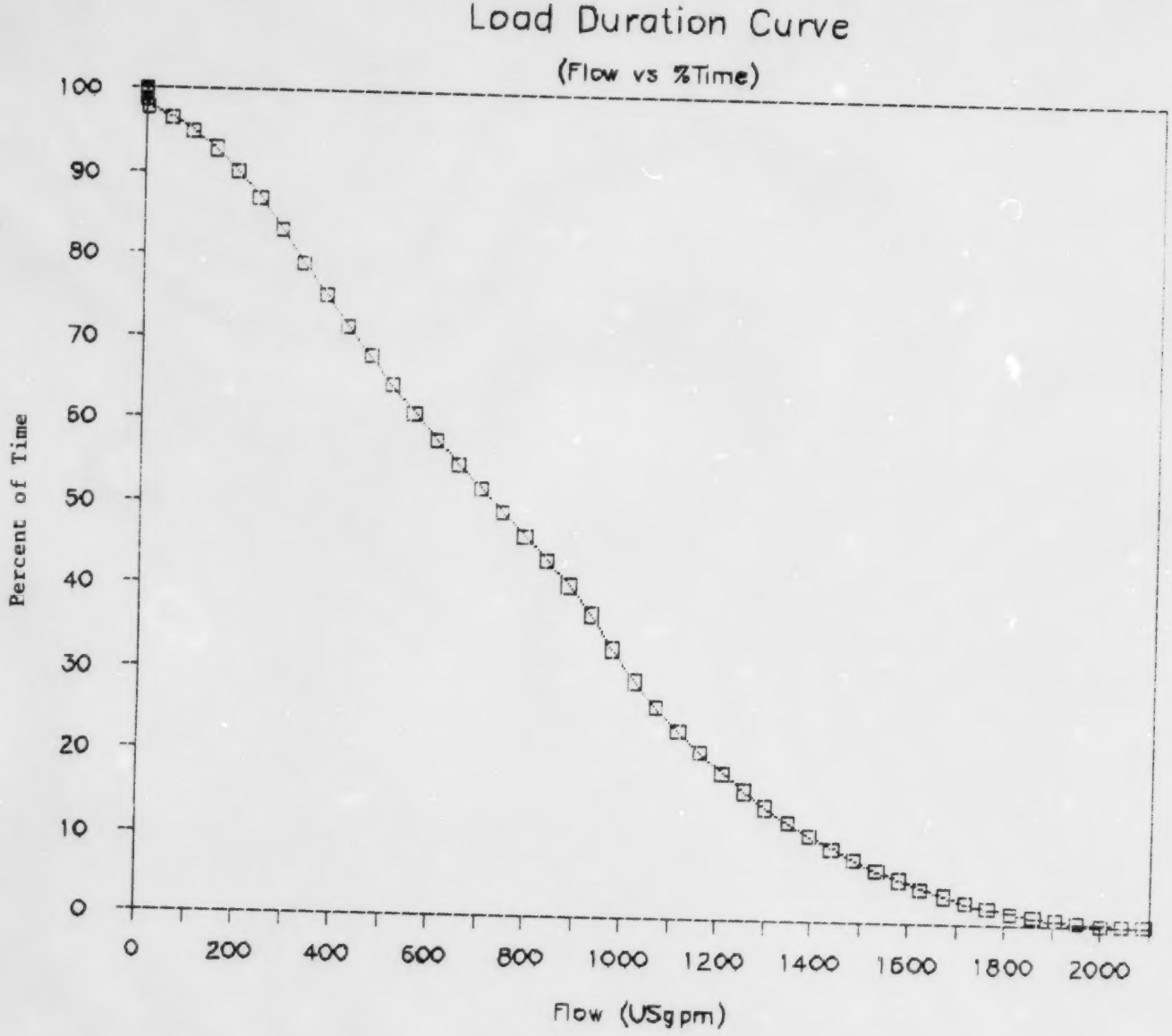

Load Duration Curve
(Flow vs %Time)
Percent of Time
100
90
80
70
60
50
40
30
20
10
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
Flow (USgpm)

Figure 2

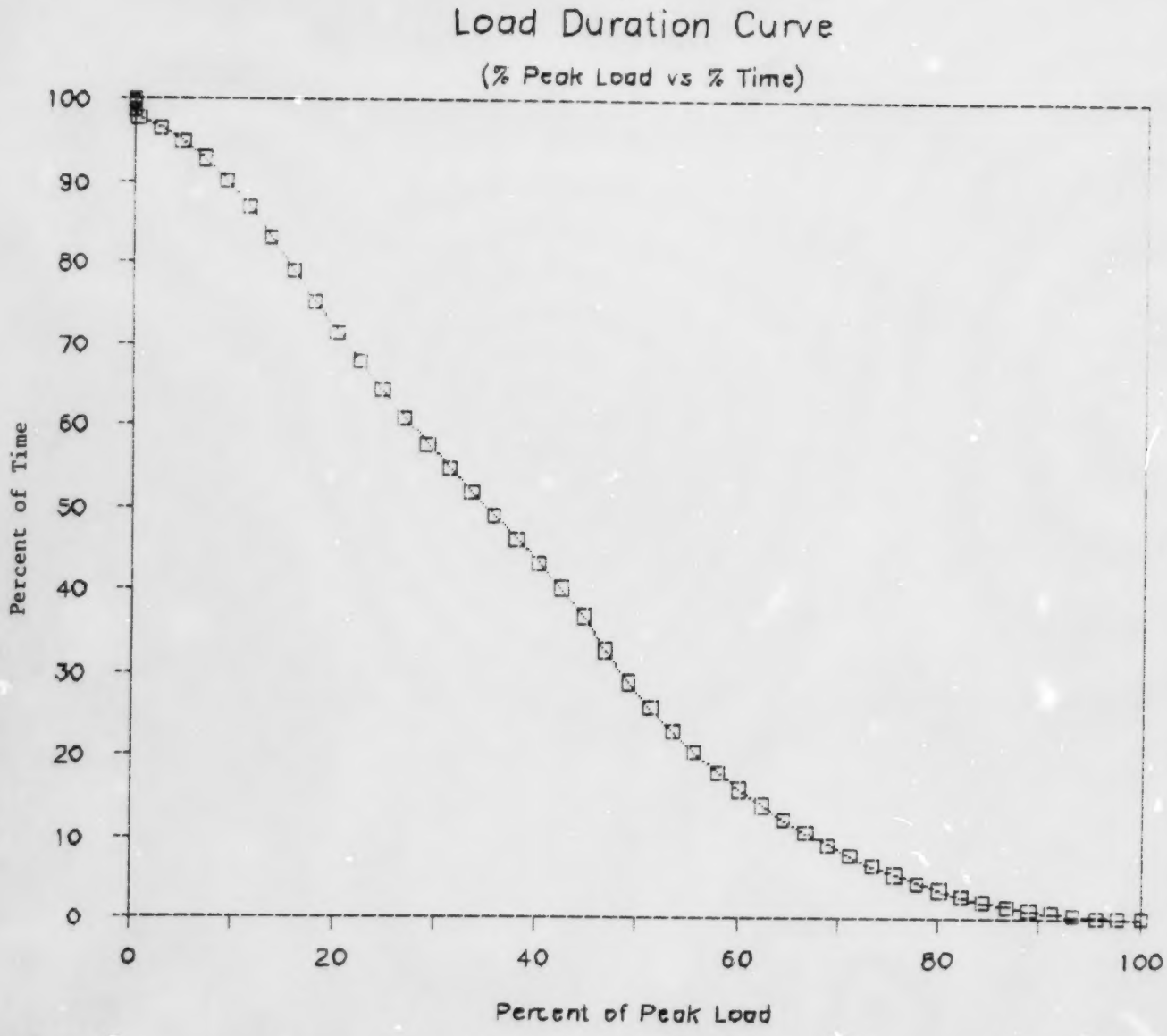

Load Duration Curve
(% Peak Load vs % Time)
Percent of Time
100
90
80
70
60
50
40
30
20
10
0
0
20
40
60
80
100
Percent of Peak Load

Figure 3

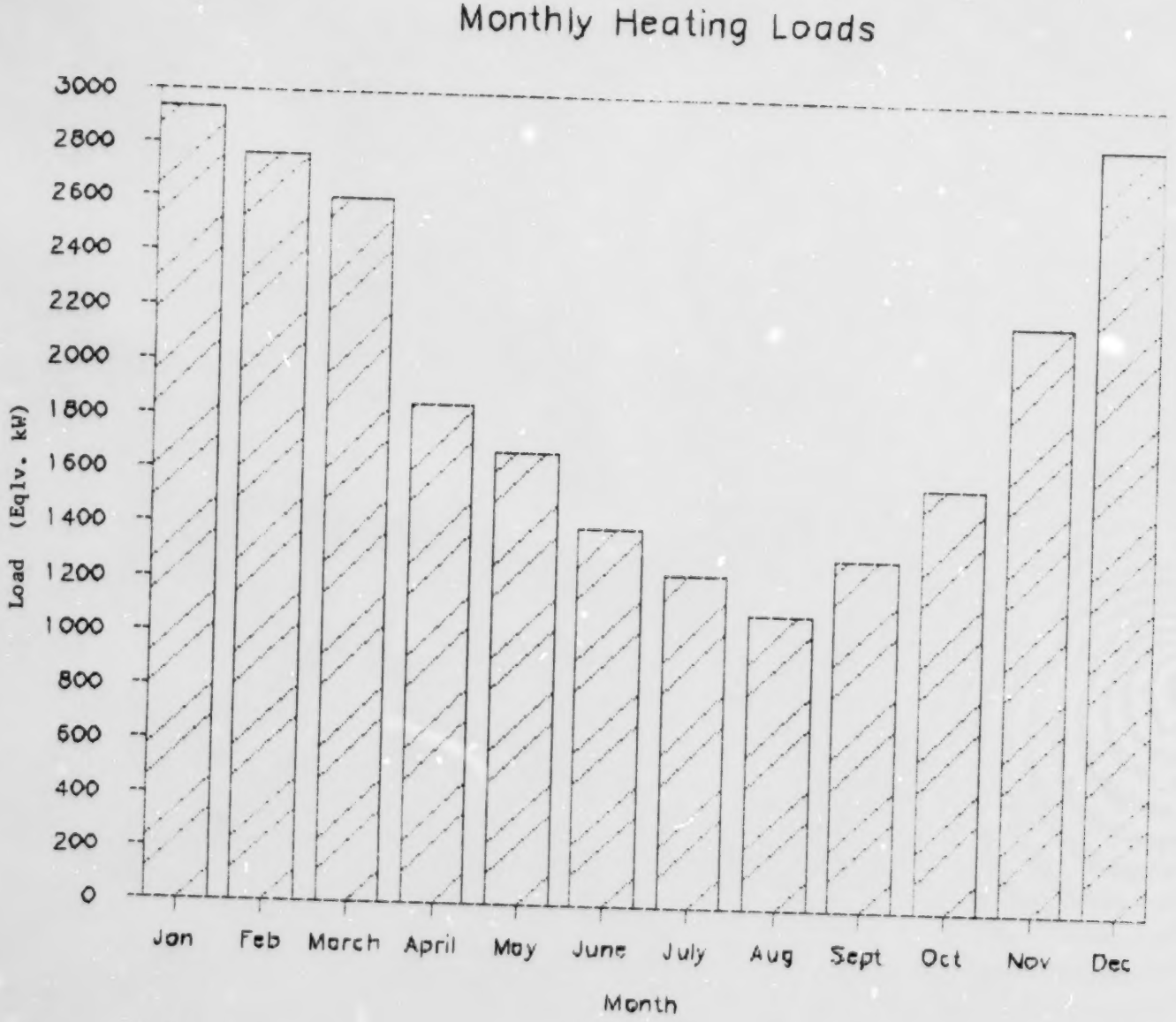

Monthly Heating Loads
Load (Eqlv. kW)
3000
2800
2600
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Jan
Feb
March
April
May
June
July
Aug
Sept
Oct
Nov
Dec
Month

Figure 4

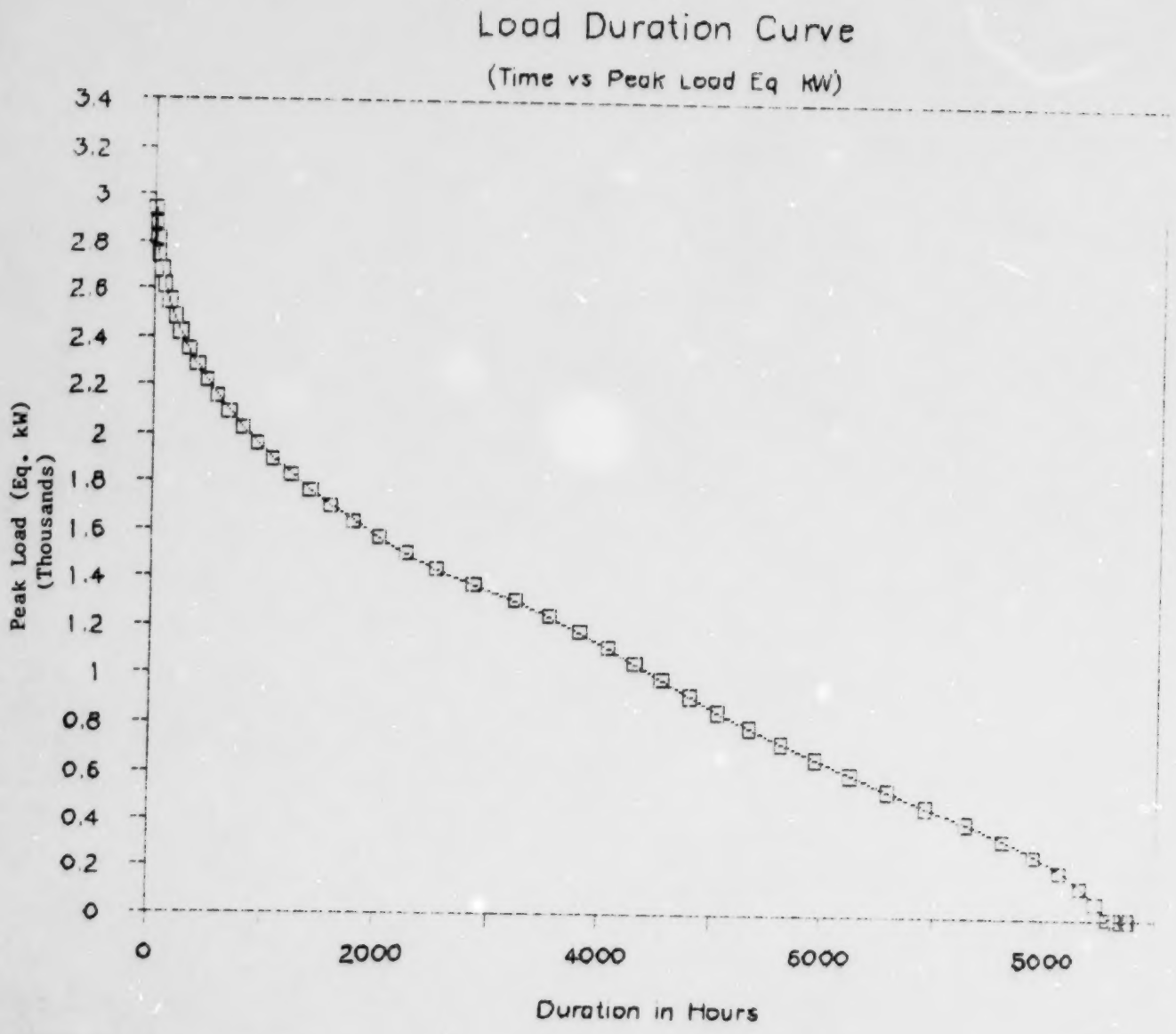

Load Duration Curve
(Time vs Peak Load Eq KW)
Peak Load (Eq. kW)
(Thousands)
3.4
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
2000
4000
6000
5000
Duration in Hours

Figure 5

2.3 ENERGY EFFICIENCY IMPROVEMENTS

During the second site visit, a sample of buildings were examined to determine if cost effective energy conservation practices could be employed to make the overall project more viable. The following buildings were examined:

Jean's Ladies Wear
Town Hall
Hicks & Lemoine Drugs
Springhill Record
Surrette Battery
NSPC Building
Ropak Can Am

The following observations were noted during the inspection:

- **Jeans Ladies Wear**: The building is heated electrically. It was found to be very drafty, with single glazed windows on the storefront, poor sealing around the main door, and heating problems.

- **Town Hall**: This building has a central distribution system and is of average construction.

- **Hicks & Lemoine Drugs**: This store has a hot air heating system ducted below floor, which is convenient for geothermal conversion. An existing window mounted air conditioner unit has poor airflow distribution due to location.

- **Springhill Record**: This building has been retrofitted and is of very tight construction. It has non-operable windows, a problem with ventilation, and a requirement for cooling. It has a hydronic heating system which is in excellent condition.

- **Surrette Battery**: This is an excellent candidate for geothermal conversion due to high heating costs for ventilation, and a requirement to dehumidify in the summer to improve comfort conditions.

- **NSPC Building**: This is a very poor building from an energy usage perspective. It is very drafty, has holes in the walls, and space temperature cannot be maintained in some rooms. This building could benefit very significantly from geothermal conversion and energy retrofit. In addition, the arena, due to its close proximity to NSPC facility, could benefit significantly, as it could connect to a combined well.

- **Ropak Can Am**: This is an excellent example of the type of building in which geothermal energy can be utilized very feasibly. It maintains relatively stable mine water temperatures, has heat reclaim on some of the process equipment, and is a fairly tight building. A dehumidification requirement as well as heating resulted in virtually no capital cost premium for the geothermal system. A very simple distribution layout and piped mine water system network to unitary geothermal units creates quite an impressive installation.

Collectively, in the downtown core, there are a mixture of buildings varying from very poor to very good in terms of energy efficiency. Most of these older buildings have limited access to ceiling and wall membranes, which would make the shell upgrade retrofit very high in terms of payback periods (in excess of 10 years). Some infiltration related retrofits, such as minor weather stripping improvements, tend to have paybacks of a shorter duration, however, the air leakage is primarily a result of poor door fits and lack of entrance vestibules which would normally result in high capital costs and payback periods.

There appears to be little that can be implemented from an energy conservation perspective that could have a significant effect on the building energy costs and the geothermal flow rates, or demand. Most of the retrofits, if implemented, would likely result in inflating the overall payback period of the geothermal system and, in fact, the system is generally more cost efficient for buildings with a high energy density (i.e. very energy inefficient) than one that is very low. It is expected that the building owners will be making some attempt to reduce the infiltration load, which is more of a requirement for comfort improvement than energy conservation.

It was noted that some buildings will be very easy to convert to geothermal as the ductwork distribution system is in place, while others will be costly as they may have a hydronic system. Collectively it is expected that the average tie-in costs will be reasonable for the end users. In some instances, such as the Records

Building, the building is so tight that a ventilation system of some sort is required, regardless of the geothermal conversion plans.

The buildings, overall, have an energy density that could be considered low on average. Some of the schools have surprisingly low energy densities which suggests that energy management practices are in effect; more so than for others communities. This may be due, in part, to the fact that, because there is so much interest in the promotion of the geothermal energy resource, energy management is a high priority for most building owners. The energy density numbers confirm that most of these buildings are fairly conservative.

In conclusion, there are efficiency gains to be made by upgrading various buildings, but as far as the entire Town is concerned, there are no dramatic effects that can be realized by implementing energy conservation strategies throughout the Town.

SECTION 3

SITE ANALYSIS

3.0 SITE ANALYSIS

3.1 GEOTHERMAL RESOURCES IN ABANDONED COAL MINES

3.1.1 Background

One of the tasks performed during the study, in an attempt to approximate the capacity of the current resource, was a review of available literature and other relevant information. The objective of this review was to provide an opinion on the feasibility of sourcing 114 l/s (1500 lgpm) of warm water for a small demonstration project on Main Street from the abandoned coal mines, and to provide recommendations for further evaluation, which should be carried out prior to commencing construction of a geothermal project.

The following information was obtained and reviewed:

- Proposal to Energy, Mines and Resources Canada for A Low Grade Geothermal Heat Demonstration Project Utilizing the Deep Abandoned Coal Mines Underlying the Town of Springhill, Nova Scotia; prepared by The Town of Springhill Geothermal Demonstration Committee.

- Town of Springhill Geothermal Committee Test Drilling and Pump Testing Recommendations Springhill, Nova Scotia. Project No. 4215, Jacques Whitford & Associates, 1987.

- Town of Springhill Geothermal Committee Demonstration Project, Report on Test Drilling and Pumping Test Results N.S.P.C. Site - Phase 2. Project No. 4215, Jacques Whitford & Associates, 1988.

- Pump Test and Summary Report, Geothermal Production Well #6, Ropak Corporation Site, Springhill, Nova Scotia, December 05, 1988. Prepared by Ralph Ross - Site Co-ordinator.

- Town of Springhill Geothermal Committee Demonstration Project (Phase 2), Report on Production Wells 8,9,10, Surrette Battery Co. Ltd., Springhill, Nova Scotia. Project No. MERH 6050; Report to: Steering Committee, Canada - Nova Scotia and Alternate Energy. Prepared by Ralph Ross Project Site Co-ordinator.

- Geothermal Mine Water Project, Commercial Application - Pizza Delight Site, Springhill, Nova Scotia; D.S.S. File: XSC89-00264-(605).A.: Number 11 and 12 Geothermal Well Report - Development and Application; March 31, 1990. Prepared by Ralph Ross; Project/Site Co-ordinator.

Information contained within these reports covers eleven out of twelve (GTW1-6, 8-12) geothermal exploration and production demonstration wells. No data was obtained on well GTW-7.

Despite the amount of work completed to date, limited understanding of the hydrogeology of the Springhill area precludes establishing, definitively, that thermal stability under high flow rates (115 l/s or greater) will be maintained over long periods of time. Flow rates of 23 l/s to 30 l/s (300 igpm - 400 igpm) at temperatures of 15.5°C (59.9°F) to 22 °C (71.6°F) have been sustained for short periods during pump testing. Clearly, a significant resource is present, though its nature is not well understood.

No data was received regarding the long-term monitoring of demonstration wells. However, some conclusions can be drawn regarding the size of the aquifer in the No. 1 and No. 2 coal seams.

Low grade geothermal resources have long been recognised in abandoned coal mine workings beneath the town of Springhill. Between 1849 and 1958, five seams were worked. Table 3-1, on the next page, summarizes the seam stratigraphy in the Springhill area, as well as provides a list of the mines and the coal seams worked.

TABLE 3-1

STRATIGRAPHY AND MINE WORKINGS
SPRINGHILL AREA

MINES AND SEAMS WORKED AT SPRINGHILL COALFIELD	COAL SEAMS	
No. 6 Slope (No. 6)		Springhill
No. 8 Slope (No. 7)		DM-Dan MacLeod
Tingley Slope (No. 7)		H-Harrison
Lloyd's Slope (No. 6 or 7)		R-Rodney
No. 4 Mine (Nos. 6 & 7)		M-McCarthy
No. 1 Mine (No. 1)		No. 3
No. 2 Mine (Nos. 1 & 2)		No. 1
Aberdeen (Nos. 1 & 2)		No. 2
No. 3 Mines (No. 3)	Joggins	No. 7
Syndicate Slope (No. 3)	J-Joggins	No. 6
McCarthy Slope (M)	Q-Queen	
Novaco Open Pit (R)	K-Kimberly	
Harrison Slope (H)	RLJ-Rector-Lawson-Jubilee	
	FB-Forty Brine/....Gesner	
	C-Chignecto	
	F-Fundy	

The Number 2 Mine reached a vertical depth of 1323 metres with workings extending 4450 metres from the pit head. This mine was closed in 1958 after a series of bumps killed a number of workers. Interestingly, the mine averaged 1310 l/s of water make during its' life. Minor workings continued until 1970.

Workings in the Number 1 and 2 seams (No. 1 and 2 Mines) were intimately interconnected. Undermining of a portion of these workings in the Number 6 and 7 seams may have encouraged the development of fracture permeability hydraulically connecting potential aquifers. Undermining of Number 3 seam may have created a similar linkage between Numbers 1 and 3 seams.

An enhanced geothermal gradient has been recognised in the Springhill area. The rank of coal in the Number 2 Seam increases down dip from a vitrinite reflectance of 0.88 Ro to 1.20 Ro. Abandoned workings are flooded nearly to surface and current thinking suggests that a large thermal convection cell has been established. The source of the enhanced geothermal gradient is likely to be hot brines circulated up along the eastern extension of the Athol Fault.

To date twelve geothermal exploration and demonstration wells have been drilled in the shallow portion of the abandoned workings. The majority of these wells have intersected the Number 1 and 2 seams though wells GTW-11 and 12 intersected the Number 6 and 7 seams.

Prior to proceeding to a large scale demonstration project the following factors need to be assessed:

- potential aquifer size;
- long-term thermal stability (including the effects of mine water recharge on temperature);
- long-term water chemistry;
- recommended source points and number of wells;
- recommended re-injection points.

Due to the limited data available comments will be restricted to the Number 1 and 2 seam aquifers. Potentially significant resources remain to be evaluated in the Number 3, 6 and 7 seams.

3.1.2 Aquifer Size

There are several factors which will influence the size of the potential reservoir, including:

- porosity of solid coal;
- porosity of old workings;

- porosity of inter-seam strata;
- permeability of inter-seam strata including induced fracture permeability of the subsidence zone due to undermining;
- thickness of coal and inter-seam strata;
- degree of hydraulic connection.

Coals of the Springhill Coalfield have been, historically, classified as high volatile B bituminous. Recent work indicates a rank variation based on vitrinite reflection data of 0.88 Ro to 1.20 Ro. Porosity within coals of this rank can vary from <5% to >20%.

Porosity of old workings is expected to be quite high, in excess of 20%. For the purposes of this study it has been assumed that the porosity of the inter-seam strata is very low (<5%), but that induced fracture permeability and mining connection between workings in the Number 1 and 2 seams have completely linked the two aquifers.

The Number 1 seam splits towards the southern part of the coalfield. Table 3-2 summarizes the extent of workings and thickness of coal worked in the Number 1 and 2 seams.

TABLE 3-2

AREAS OF WORKINGS IN NUMBER 1 AND 2 SEAMS

Seam	Area Worked	Seam Thickness
No. 1 lower split	450,000 m^2	1.2 m
No. 1 upper split	1,800,000 m^2	1.2 m
No. 1 combined	1,080,000 m^2	2.4 m
No. 2	7,500,000 m^2	2.9 m (avg.)

Underground mining methods can be expected to recover somewhat less than 40% of the coal. Hence 40% of the above areas can be expected to be voids or crushed workings. The remainder will consist of unworked coal. For the purposes of this calculation, the reservoir area has been restricted to that of the abandoned workings. A blanket 20% porosity has been arbitrarily assumed across the reservoir, and the reservoir is assumed to be 100% water saturated.

The volume of water anticipated to be held within the Number 1 seam workings is 1,058,400 m^3 or 1.06 gigalitres.

The volume of water anticipated to be held within the Number 2 seam workings is 4,350,000 m^3 or 4.35 gigalitres.

Total water volumes are conservatively estimated to be **5.43 gigalitres or 1.19 billion (10^9) imperial gallons.**

3.1.3 Thermal Stability

It is felt that there is insufficient data to establish the long-term thermal stability of the geothermal energy resource. At low pump rates, the exploration/demonstration wells achieved stability within 4 days. At higher flow rates, it is impossible to predict ground water temperatures without some knowledge of the reheat rate and the effect of recharge water.

Potential flow rates at a given temperature will only be established by actual long-term pumping tests through several seasons. Piezometer/temperature monitoring wells should be in place down dip of production wells to monitor ambient conditions and provide warning of temperature changes.

In positioning source/injection wells, care should be taken not to disturb the natural thermal convection cell present in the old workings. Mine plans should be drafted using Cad software, and a 3-dimensional model constructed to preclude creating artificial hydraulic circuits.

Potential reheat rates could be quite high if circulating hot brines are coming up along the Athol Fault.

3.1.4 Water Chemistry

If hot brines are providing a heat source, long-term pumping could be expected to result in water with increasing salinity (conductivity) and total dissolved solids content. This may suggest corrosion problems down the line. Samples should be routinely collected from down dip monitoring wells for chemical analysis.

Mines in the Springhill area were known to be gassy, and dissolved methane (CH_4) content may increase as the reservoir is pumped.

3.1.5 Source Wells

A review of available data suggests that source wells should be located at the base of Number 2 seam in collapsed old workings. The wells should be located slightly deeper than the existing demonstration wells. This will minimize the influence of immediate surface water contamination.

It is likely that two to three source wells will be needed for the 1500 igpm demonstration project.

At least four monitoring wells should be completed surrounding the source wells. Pneumatic piezometer and thermistor strings should be installed in the Number 3, 1 and 2 seam horizons. The down dip monitoring well should have the capability for obtaining water samples for chemical analysis.

One or two of the monitoring wells could also be used to assess the resource potential of the Number 6 and 7 seams. At least one of the monitoring wells should be completed into these basal horizons to assess any hydraulic connection between these coal seams and the stratigraphically higher pumping horizon.

3.1.6 Re-Injection Wells

Waste water injection wells should be carefully located so as to minimize hydraulic interference with the pumped horizon or natural convection cycles.

Number 3 or 1 seam would both be suitable. Injectivity / transmissivity tests should be conducted on both horizons in solid coal and old workings. This will aid in establishing the most appropriate location for the injection wells and the number of wells required.

3.2 MINE WATER SUPPLY INVESTIGATION

3.2.1 Overview of Past Drilling and Current Usage

The Springhill Industrial Park, and much of the northwestern side of the Town, is underlain with extensive post and tunnel mine workings at several different levels on different coal seams. Most of these mine workings between the different levels and seams are interconnected at many locations. Since 1958, when mining ceased and dewatering of the mines was stopped, the extensive voids created by mining activities, as well as the natural voids throughout the coal field, have become flooded creating a vast underground reservoir.

A good deal of information on the coal field and its potential geothermal resource was obtained during the literature study summarized in the previous Section. The results of this study were an approximation of the capacity of this reservoir to be in the order of 5.43 million cubic metres or 1.19 billion imperial gallons of water stored in Seams No. 1 and 2, which are the largest individual seams, but other seams are also extensive. Because of the depth of some of the mines, Seam No. 2 has been worked to over 1,300 m in depth. Geothermal heating occurs at the lower levels of the mines, and a natural convection current has been set up, bringing the warmer water to the surface along the main haulages of the mines, while water from the extremities of the workings, cooled by natural ground water, circulates downward to the lower depths.

There are also some theories that this natural convection current is supplemented by chemical reaction resulting in heat coming directly from the coal. This is supported by the fact that the water temperature gradients on test wells have been warmer within the coal seams than in the sandstone between the seams. However, this may also be due to simply easier flow paths resulting in short flow times for the warm water rising from the depths of the mine. Whatever the cause, the combination of the extensive deep underground coal workings and the flooding has resulted in a vast geothermal resource relatively close to the ground surface, which can be tapped for utilization with heat pumps to generate inexpensive energy.

To date, 12 geothermal wells have been drilled into these coal seams with varying degrees of success, as follows:

Well No. 1 - low yield due to not hitting any voids in the seam.

Well No. 2 - high ground water intrusion resulting in thermal contamination and inadequate temperatures for commercial use.

Well No. 3 - tested at 17 litres/second (225 IGPM) with temperature rising from 14°C to 18°C during a five day pump test.

Well No. 4 - cased for re-injection of used water and not pump tested.

Wells No. 5 & 6 - high surface water intrusion and contamination, resulting in temperatures in the range of 13°C to 14°C; although these temperatures rose with pumping, there were relatively low yields, in the range of 3 to 4 litres/second, with problems of collapsing walls through the coal seams.

Well No. 7 - no information provided to us.

Wells No. 8 & 9 - each provided over 22.5 litres/second (300 IGPM) from seam No. 1, but as it was near the surface the temperatures were cooler than desired due to surface water thermal contamination.

Well No. 10 - pumped at 15 litres/second (200 IGPM) for 48 hours from Seam No. 2 with the temperature increasing from 12.6° to 17.6° C during the 48 hour pump test.

Wells No.11 & 12 - both of these shafts were drilled through Seams No. 6 & 7 and, through the use of salt injection, it was possible to show the geothermal flow up the slope of the deeper, warmer seam and down the slope of the shallower, cooler seam confirming the natural convection. Well No. 12 was pump tested at 22.5 litres/second with a water temperature of 16° C which rose during pump testing.

All of the above wells except No. 11 and 12 were drilled into Seams No. 1 and 2. Wells No. 11 and 12 were drilled into the shallower Seam No. 7 and the deeper Seam No. 6. At the present time, of these geothermal test wells, Wells No. 6 and 7 are being used by Ropak Containers, Well No. 3 is being used by MBB Mechanical, Wells No. 11 and 12 are being used as re-injection and source wells by Pizza Delight, and Well No. 10 is available for Surrette Battery.

3.2.2 Present and Long Term Supply Objectives

The drilling of 12 test wells and the development of 3 commercial users of the geothermal resource over the past 5 years has led to a strong interest in the Town to expand both its knowledge and use of the geothermal resource. The economic analysis which has been carried out in the preparation of this report shows that the geothermal resource underlays the entire Springhill Industrial Park and surrounding areas and can provide significant economic benefits for new industries requiring extensive space heating and cooling, or the meeting of other low temperature heating requirements. They also show that there is a reasonable payback period for a project involving a small group of buildings in the core of the commercial area of Main Street.

Therefore, the current supply objective is the development of an adequate mine water supply consisting of 2 or more supply wells and 1 re-injection well in the Main Street area, to supply the heating and cooling requirements of the proposed project in this area. The long term objective is to develop sufficient understanding of the geothermal resource and how it functions so that significant new industrial development may take place in the Town's Industrial Park. Although further test drilling and long term observations on current and future wells are required to understand the full extent of the resource, the evaluation performed during this study indicate that applications to date are only scratching the surface of its potential.

3.2.3 Realization of Resource Potential

Two major problems have been encountered with the geothermal wells drilled to date. First, the inaccuracy in mapping of the old underground workings has frequently made it necessary to drill 2 or 3 holes to hit the intended pillars and/or shafts within the coal seams; and second, it has been difficult in many instances to prevent thermal contamination through extensive infiltration of colder ground

water. Precise records should be kept of all drilling activities and well development activities, so as to develop the most economical methods of overcoming these problems.

In addition, in order to enhance the natural convection currents and increase the understanding of the total heat available and the reheating time, each further development of the resource should be coupled with best possible determination of the existing natural underground flow patterns through the use of observation wells and continuous recording flow and temperature meters on all supply and re-injection wells.

Because of the sharply increased cost of larger diameter distribution piping systems, it appears that the most economical development of this resource may come through the development of numerous wells supplying geothermal energy to local areas than through the use of a few major wells. It is essential that there be an overall control and planning to ensure that these individual supplies have minimum interference with one another and with the natural convection currents.

3.3 SITE PLAN

The drawing included at the end of this report presents:

- the extent of the developed portion of the Town of Springhill which is underlain by underground mining excavations;
- the location of geothermal test wells drilled to date;
- the location of buildings within the Town currently using geothermal heat pumped from the old mine workings;
- the location of major buildings within the Town which have the potential for high energy requirements for either heating and/or cooling, and the location of smaller buildings adjacent to them in the Industrial Park and Main Street area;
- an inset showing the location, buildings, and piping for the geothermal "project" on which the final financial assessment was performed.

3.4 DISTRIBUTION SYSTEM

3.4.1 Pipe Materials and Insulation

The study revealed that the most economical approach to utilize the Springhill geothermal resource will be through a combined heating and cooling system, in which the circulating water will be approximately the same temperature as it is withdrawn from the mine. Based on this approach, the volume of water circulated and the diameter of the distribution pipes is relatively large, but the water temperatures are such that conventional water piping systems, including PVC and polyethylene, may be utilized without suffering thermal stresses. Similarly, standard, pre-moulded, rigid waterproof insulations, such as expanded polystyrene meeting CGSB 51-GP-20M, Type 4, may be used to insulate the pipe. Local municipal servicing contractors are familiar with these products, which are far less costly than the specialty products usually utilized in district heating systems. Therefore, cost estimates for the distribution piping are based upon the use of PVC pipe meeting CSAB 137.3M, and polyethylene pipe and fittings meeting CSAB 137.1-M, insulated with expanded polystyrene.

3.4.2 The Optimal Distribution System

Because the cost of pipe and insulation increases significantly with increases in size, the optimal distribution system is one in which the distribution pipes radiate outward in all directions from the central plant, so that the system consists of the smallest practical pipes going in each direction instead of having larger pipes feeding linearly in one direction from the heat source to the load. Similarly, costs will be lowest if the plant is as close as possible to the wells, and if the supply and re-injection wells are as close together as possible. For these reasons, it is recommended that the geothermal well and plant building should be located near the physical centre of the demand loads.

3.4.3 Site Considerations

The area of Town which provides the greatest concentration of heating loads and potential cooling loads is along the centre of Main Street near the Municipal Building. This area of Town is also where installation costs for a new piping system are likely to be highest because of the thicker asphalt, concrete curbs, concrete sidewalks with brick surfaces, and sidewalks extending all the way to the

legal street boundaries. For this reason, the possibility of an easement on private properties behind the sidewalks should be investigated at the time of detailed design, but for budget purposes it is assumed that it would be necessary to put the distribution piping within the street and to bring individual laterals to individual buildings. During actual design, pipes will be located so as to minimize disruptions, and to minimize lengths of excavation and restoration though use of common laterals and pipes to the maximum extent possible.

3.4.4 Capital and Operating Costs

The capital and operating costs contained in this sub-section refer to the development of the geothermal source and re-injection wells, pumping system, and distribution system. These costs relate only to the alternative involving the 11 buildings on central Main Street, based upon source and re-injection wells near the intersection of Main Street and Church Street. Although observation wells have been recommended, the costs of those have not been included in these estimates. It is possible that one or more of the existing geothermal test wells could be used for observation wells in this regard.

Table 3-3 presented at the end of this Section gives the background information upon which the prices for the distribution piping were determined. This background information was used in numerous combinations to provide input for evaluating alternatives. Table 3-4 presents an estimate of the cost for the development of two supply wells, a re-injection well, well pumps and recirculating pumps complete with electrical controls, flow meters, temperature meters, and related incidentals for the recommended project.

All prices are in current dollars, and the distribution system prices should be accurate to within ±10%, while the well development prices may only be accurate to within ±30% - 40% because of the significant unknowns. These unknowns include the limited accuracy of the mapping of old mine workings, so that multiple holes may have to be drilled in order to hit the intended shafts, the uncertainty of the amount of casing and grouting that may be required to prevent cold ground water from above the mine shafts from entering the geothermal heat source, the amount of separation which will be necessary to find an appropriate re-injection point, etc.

Regarding operating and maintenance costs, the maintenance costs for the distribution system should be relatively low, but based upon water utility experience, an allowance of 0.5% of the capital cost per year for maintenance should be adequate. The maintenance costs of the well and pumping is dependant upon the average flow demands on the system but the total operating and maintenance costs will be equal to the power costs for pumping plus approximately 2% of the capital costs.

3.4.5 Operating and Maintenance Considerations

3.4.5.1 Wells

It is recommended that at least two source wells be utilized for the 11 building project, with the water from both being piped to the heat exchanger building. There are several reasons for this:

- it will provide for a continuation of supply of geothermal water in the event of necessary maintenance on one of the wells, pumps, motors, or controls;
- it will save pumping costs, as most of the time only one supply pump will be required with the second coming on only during peak load periods;
- it will probably provide for more efficient utilization of the heat exchangers as the warmer well (it is expected that there will be a few degrees variation from well to well based on test wells to date) can be utilized during the predominantly heating season and the cooler well can be utilized during predominantly cooling season.

A further important aspect with regard to the operation and maintenance of the supply and re-injection wells are the establishment of procedures for proper record keeping. It is recommended that each well should have recording flow meter and temperature gauges installed to record the volumes and temperatures of water drawn from and re-injected into each well on a continuous basis.

3.4.5.2 Distribution System

To minimize problems in the circulating distribution system, it is recommended that electrolytes be introduced, which will decrease the possibility of etching or

placement of deposits in the heat exchangers or pipes as water temperatures are increased or decreased, and which will reduce the friction of the flowing water thereby reducing pumping costs. Selection of the appropriate chemicals for addition to the closed loop system will be done based on the source of make-up water (probably the Town's Water Utility), and upon the cost of chemicals at the time of detailed design. Beyond providing a mechanism for addition of make-up water and appropriate chemicals, the operation of the distribution system should only require routine maintenance. It is recommended that the people operating the heat exchangers should also be responsible for the operation and maintenance of the circulating pumps on the distribution system, and that the Town Water Utility personnel should be contracted to make any necessary repairs to the actual distribution piping.

3.5 REGULATORY CONSIDERATONS

Whether or not the Town proceeds with the recommended demonstration project, it is felt that steps should be taken to regulate the withdrawal of water from and re-injection of water into the geothermal resource. There is a concern that without such regulations, the resource may be misused and possibly deteriorated. Although it is not within the scope of this report to establish a full regulatory regime, it is felt that the following things should be addressed through such regulations.

- The requirement that all users of this resource install flow and temperature gauges to permanently record on a continuous basis the volumes and temperatures of water drawn from and re-injected into the mine water system.

- That re-injection of volumes equal to the volumes drawn from the resource be made mandatory, unless direction to the contrary is authorized.

- That all users must have chemical analysis of the water drawn from the resource done at least twice annually to determine if there is any change in the chemical characteristics of the water.

- That as soon as the underground workings are three dimensionally mapped in AutoCad or other format, and an understanding of the natural convection and primary heat source is arrived at, that all future geothermal projects must be designed to complement these natural convections rather than interfere with them.

- Although we recognize that the Town's primary objective is to encourage the use of the geothermal resource rather than to increase its cost, it may be appropriate to consider establishing a small charge for use of the resource, adequate to cover the cost of the amount of technical monitoring necessary to ensure that the resource is not being damaged. It is recognized that such a charge would only be feasible with substantial additional use of the resource, but it is believed that it may also be essential if this occurs.

If controls as outlined above are implemented they will add significantly to our knowledge and understanding of the resource and assist in the realization of its full potential.

SECTION 4

ALTERNATIVE SYSTEMS

4.0 ALTERNATIVE SYSTEMS

4.1 COMMUNITY HEATING SYSTEM CONCEPT ALTERNATIVES

Four main alternatives have been evaluated for servicing the heating (and cooling) loads for the Town; these are:

1. Current Practice: existing electric, oil, propane, and some air to air and localized mine water heatpumps.

2. Localized mine water heatpumps

3. Central warm water distribution system (from central heat exchangers, which would capture heat from mine water, to local heatpumps at each building).

4. Central heating plant distribution system (medium temperature hot water, using current district heating technology, from central heat pumps).

Each of these alternatives is described in the following Sections, and the advantages and disadvantages of each are summarized in Table 4-1.

4.2 CURRENT PRACTICE

This approach would consist of continuing with the practices at present, which would be to provide heating (and cooling) by the traditional methods such as electricity, oil, and propane. Individual applications such as air to air heatpumps would likely be employed where cooling is required in addition to heating, and individual applications of mine water technology similar to the MBB Mechanical and Ropak installations would, of course, be promoted to provide some marginal level of resource development. This "do nothing, cost nothing" option serves as the default option that will be implemented if nothing else supplants it and, from an evaluation perspective, it serves as a baseline by which the other options can be compared.

TABLE 4-1

ADVANTAGES AND DISADVANTAGES OF COMMUNITY HEATING SYSTEM ALTERNATIVES

Alternative #1 - Current Practice

ADVANTAGES	DISADVANTAGES
No capital cost for implementation.	No incentives for future industrial development.
No cost for promotion of resource.	Individual usage of wells yields no revenue to Town.
	Possible contamination of resource by user, effects unknown.
	Cost for traditional fuels expended by Town to utilities outside.

Alternative #2 - Localized Mine Water Heatpumps

ADVANTAGES	DISADVANTAGES
Low cost for Town.	No revenue for Town.
Low cost for promotion of resource.	Experimental approach may be risky to end users.
	May be difficult to promote to future industry due to perception of high risk.
	Possible contamination of resource by end user, effects unknown.

Alternative #3 - Mine Water Distribution

ADVANTAGES	DISADVANTAGES
Heating and cooling no problem for end user; extremely flexible	End user cost slightly higher than central (medium temperature) district heating.
Supplemental heat may be unnecessary or passed on to end user.	
Lower temperature system may have smaller heat losses and consist of low costing, more conventional distribution piping systems.	
Low maintenance costs for Town. Central system will consist of pump house only with heat exchanger, pumps and relatively simple system components.	
Significant heatpump, capital and maintenance costs passed on to end users, Town controls water only.	
Specialized technical knowledge for Town with regard to heatpumps, heating/cooling plants avoided. Knowledge of pumping systems similar to existing responsibilities.	
Can promote usage of resource to attract industry for cost-effective cooling and heating.	

Alternative #4 - Central Heating Plant & Distribution

ADVANTAGES	DISADVANTAGES
Low cost installation for end user.	Either no cooling or expensive secondary cooling loop and chillers required.
	High temperature for heating necessitates either supplementary heat oil, electricity, etc. or expensive specialized industrial grade high temperature heatpumps.
	High maintenance costs for Town for heatpumps, chillers, pumps, exchangers, etc.
	High capital, operating, maintenance costs absorbed initially by Town, but eventually paid by end user may discourage potential development.
	Risky venture to promote failsafe operation for prospective industries given the complexity of system components; heatpumps, exchangers, boilers, chillers, etc.
	Not as clean a resource given the high probability that a fossil fuel will likely be used to maintain high temperatures.
	High temperature heatpumps may require expensive or specialized service.
	Distance from Springhill to major urban centres could be a significant disadvantage for servicing complex system components.

4.3 LOCALIZED MINE WATER HEATPUMPS

The localized approach to applying geothermal mine water technology to the Town basically involves a continuation of the practices at present. Local wells are constructed to service the needs of an individual building, or perhaps a couple of buildings close to each other, if the wells have enough capacity. Deep well turbine pumps are used to supply mine water to building heatpumps that are used in turn to provide space heating, cooling, or dehumidification to the space. Experience with the mine water to date indicates that it is relatively clean, and filtration systems are thought to be unnecessary at this time.

The existing larger sites tend to have a recharge well, while the current smaller users along main street tend to dump the water into the storm sewer system. Overloading the storm sewer may be a future problem to contend with, and a review of this problem may have to be considered in the future as the need arises.

Although the installations to date have been all water to air heatpumps, water to water heatpumps could be used to supplement hydronic space heating systems, chiller systems, or to provide domestic hot water. The technology may be used as a stand alone or as a supplemental heating (and cooling) system for new installations.

In the case of conversions, back-up or supplementary heating could be provided by existing heating plants. For new buildings some possibilities would consist of tying into the water distribution system for emergency back-up usage, or a low cost supplemental heating system such as electric resistance heating elements.

4.4 WARM MINE WATER DISTRIBUTION

The warm water distribution system approach would consist of a deep well mine water pump, that would pump mine water to a building that would house a heat exchanger and a pumping station. The concept involves a closed loop water distribution system that is on the secondary side of a high efficiency heat exchanger which has the mine water on the primary side. From the exchanger, the water would be pumped throughout the Town close to the mine temperature, to individual heatpumps at each user's building. Additional components such as valves, expansion tanks, makup valves, drains, etc. would be part of the pumping station. The water distribution system would consist of underground insulated PVC piping distributed throughout the Main Street area of the Town.

The end users would tie into the water distribution system by installing a water source heatpump(s) and connecting into the supply and return system. The end user would operate the heatpump to maintain the space conditions as required.

The analysis of this alternative considered the overall cost of the project for the economic viability, and assumed that the end user cost will be the responsibility of the building user, and that the distribution system capital, operating, and maintenance costs will be cost shared to the users.

4.5 CENTRAL HEATING PLANT DISTRIBUTION (MEDIUM TEMPERATURE HOT WATER)

The area of highest heat density is reviewed to determine the feasibility of installing a centralized medium temperature hot water heating plant. This plant would consist of a central mine water heat pump to provide the base heating load, supplemented by light oil-fired boilers for peaking demand, and reserve capacity. The downtown core is an area of the highest heat density (for the Town) and a close location to the source of mine water, for a centralized heat pump plant location. The option to provide a central plant in the Industrial Park is quickly discarded because of the low heat density (for potential geothermal conversion) and the distance to the downtown core.

The site selected for a centralized plant is near the existing Pizza Delight. The estimated peak heating load is 1000 kw with an annual consumption of 1.50 MWh. It is assumed that this load can be served by two oil-fired boilers and a heat pump in such a manner that the plant would not exceed the requirements of an unmanned boiler plant. To exceed the requirements of an unmanned plant would add approximately $130,000 a year to this project in operating costs.

For this part of the study, a group of eleven buildings are selected, which are presently heated by oil-fired hydronic systems. The buildings which are presently heated by electricity are not included. The primary distribution lines would be run up Elgen Street to the seniors residence and down Main Street to the Anglican Church.

The cost estimates are based on a medium temperature district heating system with a maximum supply water temperature of 120°C and a design temperature drop of 40°C. The temperature and pressure limitations on the system would

dictate that the system fall under the Pressure and Power Piping Code. Because of this, the buried piping costs are based on a thin wall European pre-insulated bonded piping system for direct burial. The temperature and pressure limitations would also dictate that the network would be required to be a primary/secondary system with a substation at each end user building. The substation would consist of a minimum of two heat exchangers, a heat meter and controls. The heat exchangers would provide space heating and domestic hot water heating for the building by way of a low pressure secondary piping loop and the primary loop would consist of high pressure loop piping.

The capital costs associated with this proposed system are shown in Table 4.2. The underground piping and substation costs are based on installed costs in the existing Charlottetown, P.E.I. system. The central high temperature heat pump is a rough estimate as little information is readily available for this specialized equipment.

The feasibility of the central plant is based on the difference between the cost of producing heat energy at the Central Plant and the cost of producing energy at the proposed customers' site. The central plant would produce less expensive energy because of the heat pump and the ability of a central plant to purchase oil at a lower rate than a customer. It is assumed that a centralized heat pump Coefficient of Performance would be in the range of 3.5. For the purpose of this study, the above reference was used and it is assumed that the plant could provide 80% of the total energy consumed when sized for 50% of the peak load. This would result in a heat pump with a total heat output of 350 KW for this proposed system installation. The cost of energy at the plant would then be:

Light Oil @ $0.21/l	=	$0.0280/kwh
Heat Pump with COP=3.5	=	$0.02428/kwh
Combined Average Cost	=	$0.0226/kwh

If one assumes that the average customer pays $0.273/l [$0.0364/kwh] and the system would utilize 1.5 MWh/yr, it would take approximately 38 years to pay back the capital cost of the plant.

This is a conservative number without any allowances made for operating costs, maintenance costs, land costs, taxes. Based on these preliminary numbers, it would seem that a more detailed analysis is not warranted, and that the central

heating plant (medium temperature hot water) approach is not cost effective. A chiller cooling system option was considered but immediately discarded because of the enormous expense of a cooling water distribution system and the low requirements for Town cooling.

TABLE 4-2

A) Central Plant:	Peak Heating Load 1000 kw		
Arch. & Structural:	$ 78,000	$ 78,000	
Electrical:	$ 12,000	$ 12,000	
Mechanical:			
- Two 70 BHP boilers	$ 68,000		
- Oil Storage	$ 16,000		
- Ventilation	$ 4,000		
- Hydronic Acc.	$ 69,000		
- Controls	$ 24,000	$181,000	
Central Heat Pump (100 tons):	$100,000	$100,000	
		$371,000	$371,000
B) Exterior Piping (approx. 670m):	$252,000		$252,000
C) Customer Substations (approx. $ 22,000 each):			$242,000
			$873,000

Note: All costs are in 1992 dollars.

4.6 PRELIMINARY FINANCIAL EVALUATION

The preliminary financial evaluation is presented in Figure 6. The intent of this evaluation is: to examine the capital and operating costs, energy savings and simple payback for each alternative, to establish the apparent viability of each and to determine the most feasible alternative, in a relative sense. A detailed financial assessment would then be performed on this alternative. The options correspond to the technical alternatives under evaluation. The first "#1 Existing" refers to the existing conditions at present for oil and some electrically heated buildings. The analysis summarizes and evaluates the entire candidate group of buildings as one package to assess the economic viability for the entire concept. Cost sharing arrangements between the Town and the end user are not indicated by this analysis, and some cost sharing arrangement would have to be established if a particular option were implemented. The various terms used in this spreadsheet are defined as follows:

Capital Costs

End User: the total cost to the building owners as a group.
$/Ton: heatpump cost as a function of heatpump size, in tons.
$/well: end user well cost, as a cost per well.
Misc/Bldg: hook-up costs from piping mains to end user heatpump.
Building: central plant building for heat exchanger (mine water).
Distribution: underground piping cost from Central plant bldg. throughout Town.
Total: total sitework cost.

Operating Costs

Oil L/yr: fuel consumption in Litres per year.
Oil $/yr: fuel cost for consumption at present fuel rate.
Kwh/yr: electricity consumption.
Kwh $/yr: blended electricity cost for kw & kwh.

Load(KW): cooling load in KW (estimated).
Cooling Assumed Hrs/yr: assumed equivalent hours per year of cooling operation at full load.
Kwh: kilowatt hour consumption or $\frac{(kw)(hrs/yr)}{COP}$
$/yr: estimated cooling cost in dollars per year.

Central Plant

Kwh/yr : cost for central plant operation (electrical).
L/yr: cost for central plant operation (oil).
Staff: staff costs for central plant operation.
Total: total cost for central plant operation.

Total Operating Cost

Heat Tot $/yr: total operating cost for heating.
Heat/Cool $/yr: total operating cost for heating and cooling.
Total heat/cool/cent: total operating cost for heating, cooling, and central plant operation.

Maintenance Costs

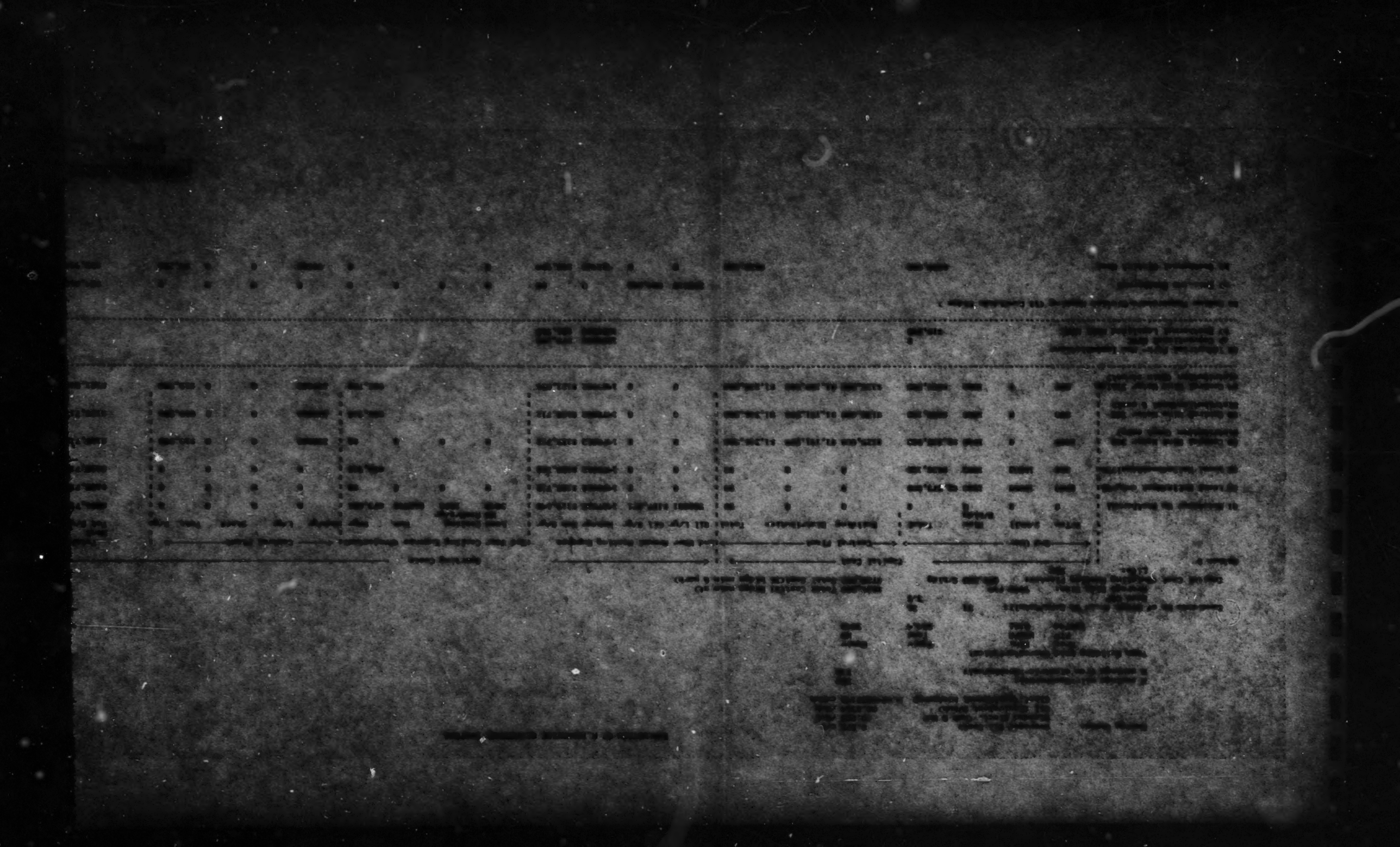
End user: building heatpump maintenance costs.
Central Plant: heat exchanger, pumps, etc. maintenance costs.

Existing Systems (Credit for Reduced Usage)

Factor for reduced maintenance and replacement costs of existing oil fired and electrical heating equipment at end user buildings (with operation of the geothermal systems the existing heating plants will achieve cost savings through reduced usage).

Total O+M: total operating and maintenance costs, including existing systems credit.

Simple Payback: a ratio of the total capital cost (end user total+central plant total+ Existing systems Credit (50%life)) over Total O+M less the baseline O+M (Option #1 existing).



Cooling Plant				Total Operating Cost			Maintenance Costs		Existing System (Credit for Purchased Energy)	Total	Simple Payback	Remarks
Design	L/yr	Staff	Total $/yr	Heat Tot $/yr	Heat/Cool/C/Cost Tot $/yr	Chiller Tot $/yr	Cont/Plant Tot $/yr	Maintenance Tot $/yr	Replacement (Credit/Tax)	$ / ft	YRS	
0	0	0	0	$256,718	$330,541	$330,541	0	0	$0	$0	0.00	Existing System Base
0	0	0	0	$125,712	$125,712	$125,712	$19,313	$0	($21,600)	($360,000)	10.14	Heat Only, Cooling not required
0	0	0	0	$125,712	$182,627	$182,627	$4,726	$0	($21,600)	($360,000)	1.76	Full Heating & Cooling
[illegible]	0	0	$19,890	$125,712	$125,712	$145,262	$18,810	$19,185	($21,600)	($360,000)	27.[illegible]	Heat Only, 20 Stage served by Central, with plenum
[illegible]	0	0	$19,890	$125,712	$182,627	$182,177	$2,826	$19,185	($21,600)	($360,000)	$175,[illegible]	7.93	Full Heating & Cooling, 20 Stage served by central with plenum
[illegible]	0	0	$19,590	$121,036	$188,824	$172,374	$1,010	$12,250	($10,600)	($310,000)	$157,[illegible]	7.23	Full Heating & Cooling, 20 Stage served by [illegible]
					$73,030 $26,863	$73,588 $26,863	$0 $75	$0 $0	$0 $0	$0 $0	$72,[illegible] $26,[illegible]	5.05 4.27	Full Heating & Cooling, Added VAV Supplemental Cooling
0	0	0	0		$84,660	$84,660	$0	$0	0	0	$[illegible]	0.00	20 complete buildings, heat exchanger for heat only system
[illegible]	0	0	$9,250		$35,994	$28,994	$1,875	$6,250	($5,000)	($110,000)	$[illegible]	10.10	Full Heating & Cooling Existing System, 20 [illegible]

[illegible]

[illegible] 8

4.7 RE-EVALUATION OF ALTERNATIVES

Based on the simplified spreadsheet analysis presented in the previous Section, it appears that district heating (medium temperature) hot water concepts are not economically viable at all. The central mine water concept for the entire Town, although more viable than district heating, also demonstrates poor financial payback. The most feasible alternative appears to be a continuation of the localized approach used to date.

The results of the previous analysis were studied carefully, from the perspective of identifying other possible approaches to developing this resource which may be potentially more feasible than those already studied. Given that the individual well concept seemed to have financial merit, relative to those projects already in place, this alternative was further reviewed as a starting point to develop other concepts. It became readily obvious that, if the piping and related civil works costs could be minimized, a significant portion of the capital cost of the project would be eliminated, and this premise became the basis of subsequent evaluation.

A natural extension of the localized well concept would be to use a "cluster" approach, and cost share a central well between two, three or more buildings located in the immediate area; consequently, extensive pipe runs would be avoided and, since this tends to rapidly inflate the overall capital cost, the economics should improve considerable. Therefore, the original development approach, which was intended to service 31-36 buildings, was scaled down considerably to eleven (11) buildings located in close proximity to each other. These buildings are shown on the Site Plan at the end of the report. These 11 buildings then become the "development project" for which a more detailed financial analysis was performed, and this is presented in Section 5. These buildings represent the "cream of the crop" in terms of building energy density, load, and proximity to each other, and are clearly suitable to illustrate the feasibility of this approach.

This "mini project", should it go to the demonstration stage, will serve to demonstrate the resource to new industrial/commercial businesses considering locating to Springhill, and will additionally demonstrate the "cluster" approach that appears to be the optional development scenario and should be promoted for further development of this resource.

SECTION 5

FINANCIAL AND ECONOMIC ANALYSIS

5.0 FINANCIAL AND ECONOMIC ANALYSIS

5.1 INTRODUCTION

This section of the report provides a financial and economic assessment of a potential community geothermal heating/cooling development in Springhill. Section 4.0 provided the information needed to identify the potentially best alternative, from a technical and cost perspective; the concept with the most potential appears to be the cluster approach. This project would require a central well, pumps and heat exchanger, and distribution piping system that would feed heat pumps at each building.

The analysis assesses a scenario composed of the following elements:

- a central well pumps and heat exchanger;
- distribution piping serving 11 buildings;
- heat pumps located at 11 buildings;
- additional equipment and related infrastructure (if required) at each building to facilitate forced air heating;
- additional equipment and infrastructure (at the 6 buildings that now have cooling) to facilitate full cooling services.

For the purposes of the financial analysis this is called the **Status Quo Scenario**, that is, the geothermal project is used to replace the heating and cooling load currently in place at the 11 building cluster.

The financial analyses is designed to show the extent to which savings would exceed costs. Savings are reflected in the conventional costs that are no longer incurred once the geothermal system is in place. The costs relate to the construction and operation of the geothermal system. The demonstration is analyzed from a total project perspective, not from the perspective of any one participant.

The economic analysis identifies the extent to which the cost savings could result in the expansion of the local economy.

5.2 FINANCIAL ANALYSIS

Financial analyses are conducted for two scenarios:

- a status quo scenario; and
- an incremental cooling scenario.

Status Quo Scenario - The financial analysis undertaken is a cost effectiveness analysis. That is, the objective is to determine if the geothermal source of heating and cooling will be less costly than the existing methods used to heat the 11 buildings in the cluster, and cool the 6 buildings of that cluster that currently have cooling capacity.

Incremental Cooling Scenario - In the second step of the financial analysis it is assumed that the owners of the 5 buildings which do not have cooling capacity are willing to make the investment to install full air conditioning services, and the owners of the 6 buildings that have cooling systems are willing to absorb the cost of removal of their cooling plants for geothermal conversion.

5.2.1 Results

Figure 7 provides a detailed description of the financial analysis for the **status quo scenario**. It shows that when geothermal sources are used to replace the existing heating and cooling systems in the 11 building cluster, benefits in terms of foregone costs slightly exceed the capital and operating costs of the geothermal system. The internal rate of return for the overall project is 2.2%. That is, the investments made to install the geothermal system earn an annual return of 2.2%.

Figure 8 shows the calculations used to estimate the relative cost effectiveness of the geothermal system under the **incremental cooling scenario**. If we assume that the 5 buildings currently without cooling forego the purchase of conventional cooling systems, and use the geothermal source instead, the overall project shows an internal rate of return of 15.7%.

When conventional sources of cooling were replaced by geothermal sources the major benefit of geothermal stems from the fact that, once the geothermal sources are in place to provide heat, very little additional operating costs are required to use this same system for cooling. On the other hand, conventional systems incur significant upfront capital costs. These cost are foregone by the 5 buildings that are assumed to add cooling.

5.2.1.1 Financial Cost Effectiveness Analysis **(Status Quo Scenario)**

.1 Financial Assumptions

The following assumptions apply to the financial analyses:

- the existing heating systems are maintained as back-up systems;
- the existing cooling systems are dismantled in year 1 of the analysis; no scrap value is assigned to the existing equipment;
- because the existing heating systems are used only for back-up purposes, the existing systems have a longer life and, therefore, no capital replacement costs are incurred during the 20 year analysis; no scrap value is assigned to the conventional heating system in the 20th year of the analysis;
- inflation remains at 5% for the entire 20 year analysis period;
- the financial analysis does not include the cost of money, expressed in interest payments, or the effect of income tax; at the pre-feasibility stage, it is not necessary to include these two cost items in the analysis;
- warm water will be sold at cost to the participants.

.2 Treatment of Borrowing Costs

Borrowing to purchase capital for a project can only increase a project's internal rate of return if the rate of interest charged is less than the internal rate of return. Similarly, if the borrowing rate exceeds the internal rate of

return then the internal rate of return of a project, with borrowing, will be reduced. In other words, financing a project only makes a good project look better and a bad project look worse. Therefore, the financial analyses performed for this study do not include borrowing costs, so that the projects can be evaluated from a "stand alone" perspective.

.3 Treatment of Income Taxes

The argument applied to borrowing is similar for the exclusion of income taxes. Income taxes only become a consideration when a positive revenue stream is shown. However, tax rates are such that they do not force a project with a positive revenue stream into a negative position. Therefore, the inclusion of income taxes in the calculations have no effect on the determination of financial viability from a pre-feasibility perspective.

.4 Benefits

The main benefits stem from the foregone costs associated with no longer operating the conventional heating and cooling systems. In the financial analysis, the full value of the foregone costs are shown (the costs associated with operating the existing system in a back-up mode are shown in the costs section of the spreadsheet).

The second major group of benefits normally stem from scrap value of the existing system and the new system. Scrap values need to be assigned so that the analysis can be closed at the end of the 20th year, as required by the Terms of Reference.

A $0.0 scrap value benefit of the existing heating system and geothermal system is shown in the 20th year. Values of $0.0 are assigned because it is assumed that, given the assumed maintenance expenditures, the systems, while still serviceable, would have no cash value.

The existing cooling systems will not be needed as a back-up. Their scrap value is shown in year 0, the first year of operation of the geothermal system. Scrap values are estimated as the cash income that could be gained by disassembling and selling the systems. A $0.0 value is assumed.

Some elements of the central plant, such as the distribution piping, may have a negative scrap value. That is, in order to decommission the system expenditures may be required that exceed any revenue that might be gained by selling the disassembled systems.

All benefits are shown in 1992 dollars. The total benefit line is also shown in 1992 dollars. Benefits are raised to their current dollar value by inflating the 'total benefits' line stated in 1992 dollars by the 5% annual inflation rate.

.5 Costs

The costs associated with the geothermal system are broken down into capital and operating elements.

The capital costs associated with the implementation of the system relate to the development of the central system, and provision of heat pumps and miscellaneous connections by the users. The central system requires the construction of a central plant building, with pumps and heat exchanger, provision of a central well and pump, and installation of distribution piping. Users must supply their own heat pumps and connections to the distribution pipe line. Ductwork to allow for forced air heating, and cooling in the buildings that are already cooled, is assumed to be put in place, where needed.

The financial analysis assumes that all capital costs are occurred in the first year.

Costs of operating the geothermal system are associated with the central plant and distribution system, the users' heat pumps and the conventional heating systems (as back-up). Costs for the central system are broken down into electricity, equipment maintenance, and equipment replacement. It is assumed that no equipment is replaced over the 20 year study period.

User operating system costs, when the system is used for heating, are broken down into their electricity, maintenance and equipment replacement components. User costs related to cooling are limited to direct operating costs in terms of electricity, as it is expected that little or no incremental maintenance or equipment replacement costs will be incurred due to the

use of geothermal system for cooling purposes. In order to provide a direct comparison to the status quo situation, it is assumed that only those buildings that currently have cooling systems will incur geothermal cooling costs.

It is assumed that existing heating systems will be maintained to provide emergency back-up services and peak load services. The operating costs of the conventional systems, in the back-up mode, are broken down into oil, electricity, maintenance and equipment replacement items. These costs are assumed to be 5% of the costs that would be associated with operation on a 'full time' basis.

.6 Cumulative Cash Flow

The sum of annual net cash flow (current dollars) reaches 0 in the 18th year of operation. This is the break even point for the status quo demonstration project. "Break even" means that the un-discounted value of costs equal benefits.

.7 Internal Rate of Return

The internal rate of return for the status quo scenario is 2.2%. The positive rate of return indicates that there are net benefits due to implementation of the geothermal project. The rate of return is much lower than current borrowing rates and, therefore, financing the project would reduce the rate of return. Given the wide range of investment choices that would yield in excess of 2.2%, it is concluded that the status quo scenario would not be attractive to potential investors.

The rate of return is a total project return. Because it is positive there are net benefits. However, at this stage of the analysis it cannot be determined which, if any, of the individual participants would be left worse off for the project. It is expected that users who need to install duct work would find that conversion to geothermal yields a negative rate of return on their investment. Conversely, those that do not need to install duct work would likely earn a return on investment somewhat above 2.2%.

5.2.1.2 Financial Cost Effectiveness Analysis **(Incremental Cooling Scenario)**

This scenario assumes that the owners of the 5 buildings that do not have cooling have chosen to install conventional cooling, but can now avoid those costs by making use of the geothermal source of cooling energy. It is also assumed that the 6 buildings that have cooling are willing to remove their existing cooling plants such that they can be replaced with geothermal units.

.1 Financial Assumptions

The financial assumptions remain the same as shown in the status quo scenario.

.2 Benefits

Benefits remain the same as in the status quo scenario, with the exceptions described below:

A scrap value for the incremental cooling systems added to the 5 buildings currently without cooling is treated as a benefit. A $0.0 value is given because it is assumed that, under normal operating conditions, a conventional system, after 20 years of use, would have no cash value.

Benefits relating to the foregone costs of operating the conventional cooling systems are higher than in the status quo scenario because:

- the 6 buildings that currently operate cooling systems forego the cost of operating and maintaining their conventional systems;
- the 5 buildings that do not now operate cooling systems are assumed to have installed geothermal systems, instead of conventional systems, and therefore, the capital and operating costs of the conventional systems become foregone costs (i.e. benefits). This foregone capital cost is estimated at $650,000.

.3 Costs

Costs remain the same as in the status quo scenario, with the exception that users' cooling costs rise, because all 11 buildings now use the geothermal system for cooling.

.4 Cumulative Cash Flow

The sum of annual net cash flow reaches 0 in the 8th year of operation. This is the break even year of the demonstration project that would replace the status quo heating and cooling situation and add cooling to the 5 buildings currently without cooling systems. "Break even" means that the un-discounted value of costs equal benefits.

.5 Internal Rate of Return

The internal rate of return for the incremental cooling scenario is 15.7% The rate of return is somewhat higher than current borrowing rates and, therefore, financing the project would slightly increase the rate of return.

It is concluded that the incremental cooling scenario demonstration project could be attractive to potential investors.

The rate of return is for the total project. Because it is positive, there are net benefits. Based on the results of the status quo scenario it is known that participants that have adequate cooling in place would see very little return on their investment in a geothermal system. Significant returns would be earned by participants that are considering installing conventional cooling systems. Going the geothermal route obviously would provide a very cost effective alternative.

5.2.2 Conclusions

5.2.2.1 Status Quo Scenario

First, from a technical perspective, the 11 building cluster provides an effective setting for a demonstration project. From a financial perspective it provides no rate of return. For the project to be undertaken an analysis must be undertaken

from the perspective of each participant. Based on the individual rates of return, each participant would need to be assisted to the point that they would earn a rate of return that would compensate for:

- the investment opportunities foregone because expenditures were made for this project; and

- the perceived risk associated with the geothermal concept.

Secondly, the financial analyses indicate that, in general, retrofitting buildings, especially where large costs are incurred to accommodate forced air heating, is not likely to be financially attractive. This is primarily due to the fact that, in retrofitting situations, capital costs are sunk costs and, in general, will have little cash scrap value. However, in special cases (eg. if the conventional system is on the verge of replacement, etc.) retrofitting to geothermal may be financially attractive.

5.2.2.2 Incremental Cooling Scenario

The fact that the mere addition of 5 cooling systems to the 11 buildings so dramatically reverses the financial results indicates that the real benefits of using the geothermal energy source are earned in start-up situations. In these cases all costs related to the installation and operation of conventional systems can be treated as foregone cost (i.e. benefits).

5.3 ECONOMIC ANALYSIS

Based on the results of the status quo scenario, it is found that there will be virtually no cash savings if the geothermal demonstration project is installed. Therefore no "new" money will be available for alternative uses in the Springhill community and no measurable economic expansion will occur.

The real economic benefit of the geothermal source rests in its ability to substantially reduce the cost of heating and cooling to prospective new businesses that locate in 'new buildings'.

5.4 NEXT STEPS

Clearly, the economic development potential of the geothermal energy source is associated with the attraction of new firms or establishment of new buildings in the Springhill area. Having demonstrated the technical feasibility of the concept, the next step is to prepare a financial analysis that demonstrates the dollar cost saving to typical 'start-up' situations. Having shown the cost savings in terms of energy use, firms must be convinced that the savings outweigh any additional real or perceived costs of locating in Springhill.

Once this case is made, industries that are large users of low grade heating and cooling, relative to their total input cost, must be targeted for a direct marketing campaign. Information on energy use and input costs, by commodity type, by industry, are available from a variety of published sources.

ECONOMIC ANALYSIS FOR SPRINGHILL TOWN HEATING SYSTEM - REPLACEMENT OF STATUS QUO HEATING/COOLING

Unless noted, $ '000's, 1992 dollars

	Year																			
BENEFITS	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Heating (forgone costs)																				
Oil	48378	48378	48378	48378	48378	48378	48378	48378	48378	48378	48378	48378	48378	48378	48378	48378	48378	48378	48378	48378
Electricity	40125	40125	40125	40125	40125	40125	40125	40125	40125	40125	40125	40125	40125	40125	40125	40125	40125	40125	40125	40125
Equipment Maintenance	6600	6600	6600	6600	6600	6600	6600	6600	6600	6600	6600	6600	6600	6600	6600	6600	6600	6600	6600	6600
Equipment Replacement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scrap value																				
- existing heating system (used as backup)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
- existing cooling system (used as backup)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
- geothermal system	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cooling System (forgone costs)																				
Electricity	11280	11280	11280	11280	11280	11280	11280	11280	11280	11280	11280	11280	11280	11280	11280	11280	11280	11280	11280	11280
Equipment Maintenance	2235	2235	2235	2235	2235	2235	2235	2235	2235	2235	2235	2235	2235	2235	2235	2235	2235	2235	2235	2235
Equipment Replacement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Benefits	108618	108618	108618	108618	108618	108618	108618	108618	108618	108618	108618	108618	108618	108618	108618	108618	108618	108618	108618	108618
Total Benefits (current $)	108618	114849	119751	125739	132826	138627	145559	152836	160478	168502	176927	185774	195062	204815	215056	225809	237099	248954	261402	274472
COSTS																				
Capital - Geothermal																				
Central System																				
- Central plant	75000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
- Well	100000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
- Distribution piping	100000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Users																				
- Heat pump and misc.	758112	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Operating - Geothermal																				
Central System																				
- Electricity	6937	6937	6937	6937	6937	6937	6937	6937	6937	6937	6937	6937	6937	6937	6937	6937	6937	6937	6937	6937
- Equipment maintenance	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750
- Equipment replacement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Users (heating)																				
- Electricity	42948	42948	42948	42948	42948	42948	42948	42948	42948	42948	42948	42948	42948	42948	42948	42948	42948	42948	42948	42948
- Equipment maintenance	5685	5685	5685	5685	5685	5685	5685	5685	5685	5685	5685	5685	5685	5685	5685	5685	5685	5685	5685	5685
- Equipment replacement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Users (cooling)																				
- Electricity	6153	6153	6153	6153	6153	6153	6153	6153	6153	6153	6153	6153	6153	6153	6153	6153	6153	6153	6153	6153
- Equipment maintenance	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
- Equipment replacement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Operating - Conventional Backup																				
Users (heating)																				
- Electricity	2619	2619	2619	2619	2619	2619	2619	2619	2619	2619	2619	2619	2619	2619	2619	2619	2619	2619	2619	2619
- Oil	2006	2006	2006	2006	2006	2006	2006	2006	2006	2006	2006	2006	2006	2006	2006	2006	2006	2006	2006	2006
- Equipment maintenance	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330
- Equipment replacement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Users (cooling)																				
- Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
- Equipment maintenance	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
- Equipment replacement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Costs	1102340	69228	69228	69228	69228	69228	69228	69228	69228	69228	69228	69228	69228	69228	69228	69228	69228	69228	69228	69228
Total Costs (current $)	1102340	72689	76324	80140	84147	88354	92772	97411	102281	107395	112765	118403	124324	130548	137067	143920	151116	158672	166605	174936
Net Cashflow (current $)	-993722	41360	43427	45599	47879	50273	52786	55426	58197	61107	64162	67370	70739	74276	77990	81889	85983	90283	94797	99537
Cumulative Cash Flow (current $)	-993722	-952362	-908935	-863336	-815457	-765184	-712398	-656972	-598775	-537668	-473506	-406136	-335397	-261121	-183132	-101243	-15260	75023	169819	269356

Internal Rate of Return: 2.2%

Figure 7

ECONOMIC ANALYSIS FOR SPRINGHILL TOWN HEATING SYSTEM - REPLACEMENT OF STATUS QUO PLUS COOLING TO BUILDINGS NOT CURRENTLY SERVICED

Unless noted, $ '000's, 1992 dollars

	Year																			
BENEFITS	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Heating (forgone costs)																				
Oil	48378	48378	48378	48378	48378	48378	48378	48378	48378	48378	48378	48378	48378	48378	48378	48378	48378	48378	48378	48378
Electricity	40125	40125	40125	40125	40125	40125	40125	40125	40125	40125	40125	40125	40125	40125	40125	40125	40125	40125	40125	40125
Equipment Maintenance	6600	6600	6600	6600	6600	6600	6600	6600	6600	6600	6600	6600	6600	6600	6600	6600	6600	6600	6600	6600
Equipment Replacement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scrap value																				
- existing heating system (used as backup)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
- existing cooling system (used as backup)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
- cooling system (incremental)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
- geothermal system	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cooling System (forgone costs)																				
Electricity	16407	16407	16407	16407	16407	16407	16407	16407	16407	16407	16407	16407	16407	16407	16407	16407	16407	16407	16407	16407
Equipment Maintenance	3251	3251	3251	3251	3251	3251	3251	3251	3251	3251	3251	3251	3251	3251	3251	3251	3251	3251	3251	3251
Equipment Replacement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Equipment (incremental)	650112	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Benefits	772873	114761	114761	114761	114761	114761	114761	114761	114761	114761	114761	114761	114761	114761	114761	114761	114761	114761	114761	114761
Total Benefits (current $)	772873	120499	126524	132850	139493	146467	153791	161480	169554	178032	186934	196280	206094	216399	227219	238580	250509	263034	276186	289995
COSTS																				
Capital - Geothermal																				
Central System																				
- Central plant	75000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
- Well	100000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
- Distribution piping	100000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Users																				
- Heat pump and misc.	750112	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Operating - Geothermal																				
Central System																				
- Electricity	6937	6937	6937	6937	6937	6937	6937	6937	6937	6937	6937	6937	6937	6937	6937	6937	6937	6937	6937	6937
- Equipment maintenance	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750	2750
- Equipment replacement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Users (heating)																				
- Electricity	42948	42948	42948	42948	42948	42948	42948	42948	42948	42948	42948	42948	42948	42948	42948	42948	42948	42948	42948	42948
- Equipment maintenance	5685	5685	5685	5685	5685	5685	5685	5685	5685	5685	5685	5685	5685	5685	5685	5685	5685	5685	5685	5685
- Equipment replacement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Users (cooling)																				
- Electricity	11280	11280	11280	11280	11280	11280	11280	11280	11280	11280	11280	11280	11280	11280	11280	11280	11280	11280	11280	11280
- Equipment maintenance	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
- Equipment replacement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Operating - Conventional Backup																				
Users (heating)																				
- Electricity	2419	2419	2419	2419	2419	2419	2419	2419	2419	2419	2419	2419	2419	2419	2419	2419	2419	2419	2419	2419
- Oil	2006	2006	2006	2006	2006	2006	2006	2006	2006	2006	2006	2006	2006	2006	2006	2006	2006	2006	2006	2006
- Equipment maintenance	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330
- Equipment replacement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Users (cooling)																				
- Electricity	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
- Equipment maintenance	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
- Equipment replacement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Costs	1107467	74355	74355	74355	74355	74355	74355	74355	74355	74355	74355	74355	74355	74355	74355	74355	74355	74355	74355	74355
Total Costs (current $)	1107467	78073	81976	86075	90379	94898	99643	104625	109856	115349	121116	127172	133531	140207	147218	154579	162308	170423	178944	187891
Net Cashflow (current $)	-334594	42426	44548	46775	49114	51569	54140	56855	59698	62683	65817	69108	72563	76192	80001	84001	88201	92611	97242	102104
Cumulative Cash Flow (current $)	-334594	-292168	-247620	-200845	-151731	-100162	-46014	10841	70539	133222	199039	268147	340711	416902	496903	580905	669106	761717	858959	961063
Internal Rate of Return:	15.7%																			

Figure 8

SECTION 6

CONCLUSIONS AND RECOMMENDATIONS

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

This study has illustrated that, of the technical alternatives considered, the most cost effective option is the installation of localized systems, and a small warm water system for 11 buildings between Elgin and Elm Streets appears feasible. The medium temperature district heating system is too costly to consider and is, therefore, not recommended for further consideration.

Financial payback is attractive for heating and cooling applications. Based on discussions with the Town, it is understood that a large percentage of the candidate building users would be willing to pay for cooling equipment. At this point, the project starts to become feasible for the mine water distribution option and becomes attractive for localized applications. It is concluded that, if most of the building users within the recommended project would be willing to pay for cooling system capital costs, then the central warm water distribution system is a cost effective concept.

The original plan to locate a central plant at the Industrial Park and pipe this system throughout the Town is too costly to consider. It would be much more cost effective to locate the Main Street system at the core of the Town to minimize piping costs, and to locate a separate industrial park plant at the Industrial Park, or use individual wells for buildings within the Industrial Park. The hypothetical Industrial Park building analysis indicates that the local well approach is a preferred and cost effective option for new buildings and plants that require full heating and cooling. The geothermal heatpump system helps to offset part of the heating and cooling plant cost that would normally be required anyway for a new installation, resulting in an almost zero payback period. Although not shown in this analysis, heat only applications would likely follow the same trend as the heat only option previously analysed, resulting in a lengthy payback period. Consequently, as a result of this investigation, it is suggested that the Town actively continue to promote this resource to clients that have heating and cooling load requirements in an effort to attract them to the Park. In the future, as the Industrial Park expands, a central plant could be considered. However, considering that the expansion would likely be in a piecemeal fashion, it would be too costly to invest a large sum of money to develop the infrastructure for industrial plants that may or may not locate here in the future.

The financial analysis suggests that the 11 buildings supplied from a small, central mine water plant would be an excellent candidate for a future demonstration project. It would help the local businesses and, at the same, time assist with establishing the security of this resource through a long term application.

Long term hydrological testing is required to establish the long term nature of this resource. It would be helpful to initiate flow testing prior to the future 11 buildings demonstration project, and also to satisfy prospective industries that the flow of warm mine water is safe and secure.

6.2 RECOMMENDATIONS

The following are the recommendations of this report:

1. Promote localized well developments for new buildings in the Industrial Park, particularly buildings with heating & cooling requirements.

2. Proceed with a geothermal demonstration project involving the 11 buildings along Main Street from the Elm Street to Elgin Street (Ann Murray Street) location. The financial analysis indicates that this project is feasible, and it will be a tremendous catalyst in the overall development of this resource in Springhill. Funding for this project should be sought immediately so that the project can be implemented, and its impact realized, in the near future.

3. Carry out 3-D modelling of the underground workings, such that this work can be used to predict the effects of pumping & re-injection points to reduce the chances of any short circuiting.

4. Perform large scale flow testing in the Industrial Park and along Main Street in the vicinity of the potential future demonstration project to obtain the necessary information to better assess the capacity of the reservoir and its thermal stability.

SECTION 7

TECHNOLOGY TRANSFER

7.0 TECHNOLOGY TRANSFER

7.1 GENERAL

Geothermal energy is a resource that needs to be evaluated for development whenever the supply is relatively abundant and located in close proximity to the demand. Of significance in the matching of the supply to demand is the availability of large loads that are capable of fully utilizing this resource, i.e. hospitals, industrial or manufacturing plants, large buildings, clusters of smaller buildings in close proximity to each other, institutions, university campuses, large housing developments, etc.

The piping distribution system is a very significant cost component the project, and the distance separating the source and the various buildings is extremely important. Close proximity of large building loads to the supply source can yield attractive payback periods and, conversely, as was determined for the original scenarios developed for this project, the financial viability of the project diminishes quickly as the distance between source and load increases. This, of course, will vary considerably with the actual size of the load, but for communities such as Springhill, which is typical in size and load density to many mining communities in Canada, this will be the case.

The use of this technology for new buildings that require heating and cooling is very attractive, and this technology should be actively promoted for these applications. Where significant loads (demand) and supply do occur, then long term hydrological testing should be conducted to verify the extent of the resource and limit undesirable consequences such as low flow, drop in temperature, or short circuiting.

7.2 ISSUES FOR CONSIDERATION

The issues discussed below should be considered for communities that may be able to benefit from the utilization of this resource.

7.2.1 Fuel Flexibility

A community heating system utilizing a geothermal source is ideally suited for areas with high fuel costs, whether it be for oil or electricity. It would likely be unattractive for low costing natural gas, and very attractive for remote communities with expensive fuel oil, propane, or electricity.

7.2.2 Customer Responsibility

Customer responsibility varies with the type of installation and method of energy supply. For areas of large demand, a high temperature district heating scheme may be appropriate, with a municipal utility having responsibility for supply of high temperature water directly to a heating distribution system in each building. In such a case, the customer would have no more responsibility than he/she would have for a conventional heating/cooling system, and maintenance costs would be less because the heating source is elsewhere. The utility would be reimbursed directly for quantity of water delivered at a certain temperature, or indirectly via a municipal tax scheme. For smaller installations, such as in Springhill, the system will likely be medium temperature warm water pumped to individual heat pump systems in each building. In this case, the customer will have higher capital costs and potentially higher maintenance costs, but presumably will pay proportionally less for the energy.

7.2.3 Maintenance

When dealing with geothermal heatpump systems of the type recommended in this report, there are compressors, pumps, heat exchangers, etc., which all require additional maintenance, and this should be factored into the economic assessment. These costs should be determined for each system installed in each town, as they differ from system to system.

7.2.4 Environmental Benefits

The use of this resource is environmentally positive, because it reduces fuel and/or electricity consumption. This in turn reduces emissions discharged to the atmosphere. The environmental benefits should certainly be included in the promotion of this resource.

7.2.5 Electrical Demand

There are potentially good opportunities for reducing the electrical demand for certain buildings, particularly those with electric heating and high cooling loads. This benefit can be realized for buildings or complexes that currently have a billing demand charge. The large thermal mass storage of the mine water can be used to smooth out the peaking effect of demand curves.

APPENDIX A

EMR COMMENTS ON DRAFT FINAL REPORT

AND RELATED RESPONSE

Energy, Mines and Resources Canada
Canada Centre for Mineral and Energy Technology
CANMET
555 Booth Street
Ottawa, Canada
K1A 0G1

Énergie, Mines et Ressources Canada
Centre canadien de la technologie des minéraux et de l'énergie
555 rue Booth
Ottawa, Canada
K1A 0G1

Energy Research Laboratories

April 1, 1992

Mr. Wayne Lewis
Vaughn Engineering
1577 Granville St.
P.O. Box 2045, Stn. M
B3J 2Z1

Dear Mr. Lewis:

The draft report on the feasibility of using mine water to heat and cool the town of Springhill has been reviewed by our staff and it appears that you have done a thorough job investigating the different scenarios. However there are some concerns that we would like addressed.

A. In the terms of reference it was stated that the study would include advice or guidance for other communities that may be able to benefit from similar opportunities, these elements seem to be missing. This report is important in that it will be passed on to other communities with situations similar to Springhill's whom then should be able to assess their particular circumstance. We would like to see in the section tabulating advantages and disadvantages a less bias listing and inclusion of such items as fuel flexibility, customer responsibility, maintenance, environmental benefits and electrical demand.

B. The major cost of most district and cooling projects is consumed by the distribution system, yet no detailed basis of costing, layout designs, excavation and material costs, nor optimum pipe diameters can be found. This is a very important area and we would like to see it incorporated in the report.

C. It is evident that the central district plant alternative is difficult to justify economically in this particular case, however could you comment on where the economics would begin look good from an increasing load perspective? Also in many

D. district heating systems the customers are not only buying

energy from the district heating utility but a total service package. Could you comment on the "town" (using the central plant option) selling a energy service to its customers and how would this impact economically on the central plant alternative?

E. There are also a number of other points some of which that we would like clarified or corrected.

1. The heating load in the summer months appears to be high as compared to the winter months yet the load duration curve does not level off at some finite value but rather declines to zero. Could you please clarify? What about the domestic hot water load, is it incorporated in the load duration curve? Is the load duration curve based on the thirty six buildings or the eleven?

2. The temperature drop on page 36 was selected at 40°C, this seems somewhat low. What would be the economic impact of a temperature difference of 55°C as is common in Sweden?

3. In 2.2.2 are you stating that the base load with mine water will be 95% of the total heating load, please clarify? Also expound on the existing oil fired systems that you refer to?

4. On page 13, last two paragraphs, please comment on the heat demand that would make energy conservation economical. Indications from Sweden is heat demands that exceed 250 kw/m2 would make energy conservation economical. Also should it not be less costly to convert hydronic systems, please comment?

5. On page 18, top paragraph, the increase in reflectance of the vitrinite may not be due to an increase in rank but rather due to oxidation of the coal.

6. Could you comment on the mine water side of the heat exchanger with respect to the corrosion aspect?

7. On page 37, is the combined average cost correct?

8. On page 38, the backup oil boilers seem to be too small

for the peak load. A backup load of 60% to 100% of peak load is standard in Sweden, please comment?

9. Figure 6 appears to be quite complex, could this important information be simplified?

Yours truly,

Lynn Clavaglia
Energy Systems Technology Implementation

SPRINGHILL GEOTHERMAL STUDY

RESPONSE TO EMR REVIEW COMMENTS

A. Technology Transfer

This is presented in the report as Section 7.

B. Distribution Costs

One of the most significant costs incurred in the implementation of district heating and cooling projects is the distribution system, and this was dealt with in considerable detail during the execution of the study, as further noted below:

1. Various types of pipe material and insulation were investigated, and those found to be most economical for an application of this nature were selected as the basis of the piping system costed during this study.

2. After this analysis, composite prices for each applicable pipe diameter for pipe material, pipe installation, insulation material, installation of insulation, excavation and restoration were developed for both single pipe and double pipe trenches, where the return line could be installed in the same trench in order to reduce overall costs. Tables containing these costs are provided at the end of Appendix A.

3. For purposes of this study, it has been assumed that the pipes would be installed in relatively shallow trenches, with average cover of 18", so that they would not reach a depth where they would interfere with other municipal services, and so that excavation costs could be kept to a minimum.

4. The plan presented at the end of the report shows pipe diameter, length and flow rate in USGPM for the distribution system for the recommended demonstration project. Similar plans were prepared in the form of working drawings for the other systems considered.

5. Flow rates used were those determined at the required rates of flow for purposes of meeting the energy demand. Pipe diameters were determined on the basis of using the smallest diameter pipe which would carry this flow rate with a friction loss of equal to or less than 3' per 100' of length, which is the level of energy loss which has been previously found to provide the most economical combination of capital cost for pipeline and pumping costs for water transmission systems.

Since the distribution system will be a closed loop system, the possibility of using polymer additives to reduce friction loss and to potentially reduce the pipe sizes was not investigated, but this is an avenue which may bear investigation if the project proceeds to detailed design.

C. Economics vs. Load for District Heat

The central district heat option investigated had a heat load per metre (MWh/m) of trench of 2 MWh/m. Some studies suggest that Swedish towns have an "average" load density of 8 MWh/rn and a "low" load density of 3 MWh/m. The existing district heat network in downtown Charlottetown has an approximate load density of 8 MWh/m. These statistics, and the payback and load density compiled in this study, suggest a minimum load density of 6 MWh/m would be required before a more detailed investigation would be justified. One should be cautioned against using these general load density numbers, as costs and paybacks can vary significantly depending on the project.

D. Other Benefits of District Heat Including an Energy Service

Table 4-1 of the report contains a summary of advantages and disadvantages of the central heating plant option. This table could be expanded to add the following advantages:

1. Reduction in local stack emissions can be achieved by replacing many individual oil fired boilers (for peaking) with a single more efficient plant. Also, better dispersion of emissions can be achieved from a single tall stack.

2. Reduction in the number of above and below ground oil storage tanks at individual buildings can be achieved. The cost of replacing these tanks typically involves significant capital outlay by building owners. In a district heat system, the building owners' tanks are often eliminated or replaced with a smaller above ground tank for emergency back-up only. Also, the reduction of tanks results in a decreased chance of ground water contamination from oil leaks.

3. District heating central plants typically operate more efficiently than smaller commercial heating plants. This, in addition to the fact that building owners only pay for energy used can result in lower customer energy bills depending on the rate structure of the utility.

4. The installation of a district heat substation will free up floor space if the existing boilers are removed.

5. In a typical district heat system, the energy utility provides the service and maintenance on the substations. This provides the customers with a reliable heat source and results in savings in maintenance dollars.

6. A district heat plant can produce significant savings in labour if a single manned boiler plant can replace several smaller manned boiler plants.

More specifically, items 2, 3, 4, and 5 above can be quantified on a customer by customer basis to help offset the capital costs of connecting to the system.

E. Other Points Noted in EMR Letter

1. The monthly heating load, Figure 4, represents the maximum demand for heating that could occur for the month, and it does not include any duration component. It is therefore, not unusual for the maximum demand to be significant in the summer months, however, the duration would typically be quite small.

   The load duration curves represent the cumulative time in percentage or hours that a particular load will occur. These curves do not refer to any specific month and, naturally, as the load in KW or US gpm gets lighter, the number of hours per year will approach zero.

   The domestic hot water load is not included in the load duration curves, and these curves are based on thirty-one (31) buildings.

2. The temperature drop of 40°C is a conservative estimate based on similar buildings in the Charlottetown District Heat system. The Swedish systems are designed around a temperature drop of 55°C, but their buildings are designed to be heated with lower supply water temperatures and higher temperature drops on the secondary side. The higher design temperatures, up to 93.7°C, and lower temperature drops (8.3°C) in many local buildings limit the achievable temperature differential on the primary side of the building heat exchangers.

3. The mine water system should be designed to handle the heating load for up to 95% of the hours in a year, and this could, in fact, be described as the base load. There is a rapid escalation in load (and gpm) for the last 5%. Given the town diversity, the system which is sized for 95% may, in reality, provide up to 100%.

   Existing oil-fired systems refer to existing building heating plants which would be retained and used for supplementary heating. For a small portion of the buildings, this would consist of an existing electric heating system.

4. Heat demands in excess of 250 watts/m^2 should, in general, make energy conservation retrofit measures economical to implement. In fact, depending on the nature of the retrofit (ie, not capital intensive), buildings with heat demands between 200 and 250 w/m^2 may also be improved economically. The nature of the retrofit(s) is the deciding factor.

   Hydronic systems, when converted to a heating and cooling system, will be much more expensive than an air system, since the cooling component dictates that an air system will be required. The hydronic conversion will consist of either a conversion to an all air system or a piped system for heating and an air system for cooling. Both of these would be more expensive than an air system conversion. The costs would be similar only for "heat only" applications.

5. Relative to the statement that increase in reflectance of the vitrinite is due to an increase in rank, this is a conclusion drawn by Vaughan's sub-consultant, AMCL. Other conclusions may be possible, and could be the subject of subsequent debate.

6. Corrosion resistant materials should be selected for the design of the heat exchanger, and consideration should be given to the chemical analysis of mine water during the equipment design. Information reviewed to date indicate that extraordinary costs will not be incurred to prevent corrosion.

7. The following corrections should be made to this section of the report:

Average Energy Cost:	$ 0.0250/KWh
Heat Pump Size:	500 KW

8. The proposed boiler plant investigated consisted of two 70 BHP oil fired boilers and a single heat pump at 500 KW. This arrangement would provide the flexibility of having any one device out of service and still meet the peak heat load. This would provide the plant with 2/3 reserve oil capacity. The important parameter is to avoid the cost of a manned boiler plant if possible.

9. This information cannot easily be simplified. This spreadsheet can be rearranged into a number of different formats to suit individual requirements but not within the mandate of the original study.

TABLE 1

Composite Prices Upon Which Distribution System Costs for Various Alternatives Were Based

(Prices are per lineal foot)*

Diameter	Pipe Fittings **		Insulation		Excavation and Restoration	TOTAL	
	Material	Installation	Material	Installation		Single Pipe	Double Pipe ***
2"	$3.00	$2.00	$9.00	$2.50	$18.00	$34.50	$51.00
4"	$4.00	$3.00	$10.00	$3.00	$18.00	$38.00	$58.00
6"	$6.00	$4.00	$11.00	$3.50	$24.00	$48.50	$73.00
8"	$9.50	$5.00	$12.00	$4.00	$24.00	$54.50	$85.00
10"	$14.00	$6.00	$12.50	$4.50	$24.00	$61.00	$98.00

* Because the available background mapping for the Town and several of the past reports are in Imperial units these cost estimates have been developed based on Imperial units.

** An allowance of approximately 15% of pipe costs has been included to cover the cost of fittings.

*** Double pipe includes carrier and return in one trench.

NOTE: An allowance for design and contingencies, Nova Scotia Hospital Sales Tax, and Federal GST must be added to the above prices.

TABLE 2

Estimated Capital Costs for Well Development and for Well and Distribution Pumps for Recommended Demonstration Project

1.	Well development including drilling, testing, pumps, controls, metering, etc.	$100,000
2.	Circulating pumps and controls to be housed in heat exchanger building.	$22,000
	Subtotal	$122,000
3.	Design and Contingency Allowance 15%	$18,000
	Subtotal	$140,000
4.	GST 7%	$9,800
5.	PST (estimate)	$5,200
	Total Estimated Costs	**$155,000**

APPENDIX B

TOWN OF SPRINGHILL'S COMMENTS ON DRAFT

FINAL REPORT AND RELATED RESPONSE

Page	Paragraph	Comment
1	2	Heat only applicants can have payback periods in the order of several years. (define)
3	1	Long term flow testing of mine water needs to be completed to establish the extent of the resource. (check JWA report)
3	2	First 3 lines (please compare cost)
3	1	How much funding for extended testing would be needed.
4	2	Institution; water to the institution from the mine is only 1400' away. Again Kris Kavanaugh would verify this.
5	Figures	Temp Deg C, Duration (hours) confusing, explain
15		. You can check with Ralph Ross 597-3773.
16		Regarding Well #7, this is in John Booth report
17		Report on Springhill Coalfield incorrect, check with Kris Kavanaugh.
17	last	No, that is wrong, the tunnels are interconnected, their was no linkage.
19		Degree of hydraulic connection. see JWA Report.

Page	Paragraph	Comment
20		Regarding volume of water, (consider recharge data v/s volume, interconnects with other seams.)
21	4	Two of 3 wells, 1500 IGPM for 11-14 buildings for demonstration site seems too high.
23		Well No 7, is #3 seam
26		No concrete sidewalk. all sidewalks and brick surfaces.
29		3.5 regulatory consideration #1 - is done, #2 - is done #3 - cost consideration
35		We have 2 smaller buildings on Main St using town water and dumping into the sewer, but once the geothermal lines are run, they will be hooking up to it, thus avoiding the dumping of water into the sewers.

SPRINGHILL GEOTHERMAL STUDY

RESPONSE TO TOWN OF SPRINGHILL REVIEW COMMENTS

Page 1, Paragraph 2

The payback period could be very long for a geothermal conversion for a building that only requires heating; i.e. no cooling or dehumidification. Once cooling or dehumidification is defined as a mandatory requirement, then a refrigeration system is required anyway, and the geothermal heatpump system represents a small incremental cost leading to a shorter payback period.

Page 3, Paragraph 1

Regarding the long term flow testing of mine waters, a program similar to the following is recommended:

1. A minimum of 3 test well sites should be selected, as close as possible to potential energy customers, preferably the Main Street demonstration project, but sufficiently far apart as to not cause serious interference drawdown. It is probably appropriate to initially drill these wells using a smaller drill and, when the mine workings are successfully located, then a larger shaft can be used to ream out the wells. The actual maximum pumping rate and head and, therefore, the size of shaft required to accommodate a pump which will pump at that rate would be determined after consultation with Nova Scotia Department of Natural Resources Personnel, who are very knowledgeable with regard to the various workings.

2. At least 3 small diameter wells should be drilled for observation purposes to assist in defining the internal flow regime in the mine workings.

3. The test wells should be pump tested at the maximum potential yield for an extended period of time, until the temperature and flow rate stabilize with no significant change over a period of at least one week. It is estimated that the time required to reach this stable condition may be 2-3 months, and pumping rates in the range of 800-1000 GPM, or even higher, if possible, are suggested. During this pump test period the water levels in the other 2 wells and observation wells, the discharge water temperature, and discharge flow rates should be monitored daily. In addition bi-weekly chemical analysis, to detect any changes in water chemistry which may affect future heat exchanger design, is recommended.

After the first well has been tested, the testing equipment should be moved to one of the other wells and similar testing carried out, although a shorter time frame of a few weeks will probably provide adequate results extrapolating from the results of the initial testing. This should subsequently be repeated for the third test well.

4. In addition, during this testing period, observations should be made with regard to the impact of these test wells on the present producing geothermal wells, i.e. drawdown and water temperature.

The above testing program is suggested rather than simultaneous testing of each of the 3 wells to reduce the equipment costs. For the above testing program it is suggested that the Town purchase the test pump and related equipment, which should be suitable for use, as should the test wells, in the future operation of the potential demonstration geothermal project, so that the monies expended in the purchase should be useable over the long term while providing the optimum equipment for testing purposes. In addition, it is recommended that either chemical analysis, or the addition of salt and testing for conductivity variances be used to establish the flow patterns within the mines. It is further recommended that a 3 dimensional computer model of the underground workings be made prior to the selection of the test well site, and that the data obtained from the test wells, observation wells, and testing for flow directions be used to upgrade the model for purposes of developing a better understanding of the way the underground geothermal regime works and, from that, the optimum manner in which to utilize this resource.

On the basis of the information currently at hand, it is felt that the cost for the development of the 3 dimensional computer model, and subsequent upgrading of the same, together with the test drilling program consisting of 3 test wells and observations on the existing producing wells and 3 additional small diameter observation wells, would be in the ball park of $100,000. With proper site and equipment selection a considerable portion of these costs could be applied against a future demonstration project.

The appropriate next steps to be taken to carry out such a testing program are as follows:

1. After discussions with the Town representatives and Nova Scotia Department of Natural Resources officials to obtain all necessary background information, a Terms of Reference should be prepared to have a firm with expertise in the areas of hydrogeology and mining to develop a three dimensional model of the underground workings and to oversee and coordinate the testing program. This should be done in consultation with the Town after decisions have been reached with regard to the most desirable demonstration project, so that the test wells can be coordinated with the project's requirements.

2. After the first part of the modelling has been completed, and the probable flows at each test well and the depths from which these waters will have to be pumped are known, it is recommended that the Town purchase the equipment appropriate for conducting the long term pump tests, including a submersible electric pump of the appropriate size and capacity, a continuously recording temperature gauge, and water depth sensors to measure the depth of draw down in the well. Supplementary equipment to that which the Town will require for long term use should be supplied on a rental basis by the well driller or hydrogeologists overseeing and interpreting the tests.

.3 Separate tenders may to be called for the drilling and placing of the appropriate testing equipment, or this could be included as part of the proposal call for the engineering and hydrogeological services.

Page 3, Paragraph 2

The cost of retrofitting an existing building is generally more expensive than new construction, due to tie-ins with existing equipment, demolition and reconditioning of surfaces, and the fact that certain components of work cannot be blended in with on-going construction tasks. For new construction, the installation of a geothermal heatpump heating/cooling plant for the building is only marginally greater than the installation cost of an oil-fired heating plant, and electric refrigeration system. Consequently, the incremental new construction costs are quite attractive in comparison to total retrofit construction costs.

Page 5, Figures

The temperature is the outside ambient air temperature in degrees celsius, and the duration represents the number of hours in a year that this occurs. There are 8760 hours in a total year and, for example, for the Town of Springhill, there is 1 hour at - 28°, 210 hours at -4°C, and 1 hour at 27°C. This is basically climatic weather data which is cross-referenced to the load.

Page 15

The Jacques Whitford and Associates Ltd. report 1988 was supplied by the Town together with other information, and he data contained there-in was reviewed.

Page 16

The additional information in the John Booth report regarding Well No. 7 did not materially affect the conclusions or recommendations with regard to the requirement for further testing.

Page 17, 19, 20, 21

All of the work for Section 3.1 of the report was conducted by Vaughan's sub-consultant, AMCL Ltd., who in turn relied heavily on the previous Jacques Whitford and Associates Ltd. reports and various other data referred to in Section 3.1.1 to reach their conclusions. Their indication as to the potential yield from source wells can only be confirmed or revised on the basis of future high volume pump testing.

Page 23

The information provided by the Town that this test well tapped into No. 3 Seam is accepted.

Page 26

It was incorrectly assumed the brick sidewalk had been laid as a surface over the existing concrete sidewalk which is commonly done in other areas. It is understood, through subsequent conversations with the Town Works superintendent, that the concrete sidewalk was removed, gravel and sand placed, and the bricks placed on a sand bed.

This will reduce the disruption caused by the installation of distribution piping, and most of the bricks will be salvageable and will be able to be reused. However, while the ability to reuse the materials will reduce the supply costs which would have been associated with a new concrete sidewalk, it will increase the amount of hand work required. Although possibly reducing the excavation and restoration costs by $1 or $2 per foot of pipe, this represents only 2% or 3% of the average installed costs for the distribution system, and it is not anticipated that it will materially effect the overall budget projections and feasibility analysis.

Page 29

Regarding mandatory chemical analysis of water drawn from the resource, it would perhaps be appropriate, recognizing the cost consideration, that the frequency of testing be based on volumes used as opposed to semi annually, so that small volume users would not be faced with this charge, but large volume users that derive a significant benefit from the geothermal resource could assist the Town in monitoring any changes.

Page 35

Acknowledged; and a good point.